INDUSTRIAL RESEARCH & DEVELOPMENT

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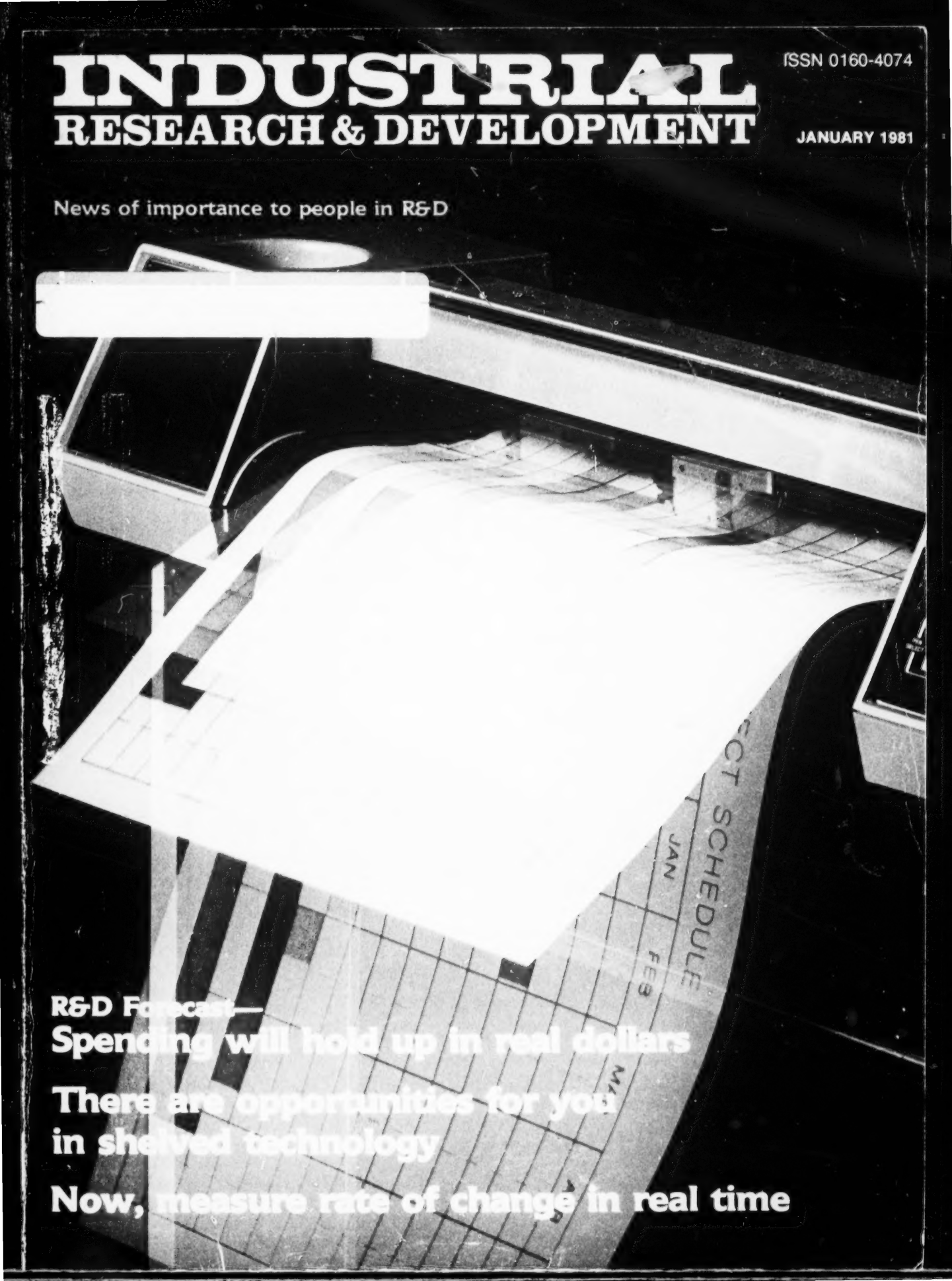
News of importance to people in R&D

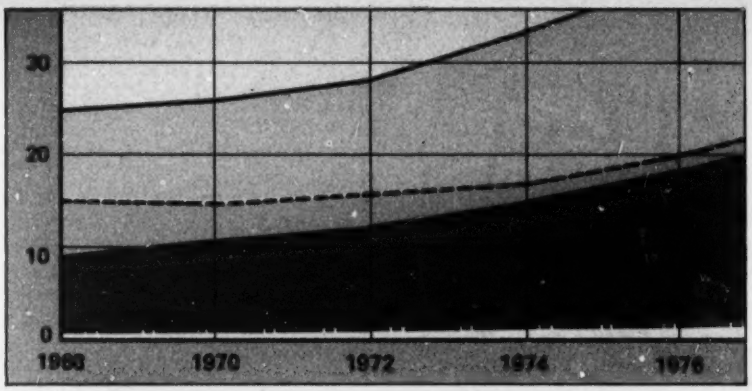


R&D Forecast—
Spending will hold up in real dollars

There are opportunities for you in shelved technology

Now, measure rate of change in real time

Sources of R&D funding — see page 114



INDUSTRIAL RESEARCH & DEVELOPMENT

SERVING THE $142.5-BILLION WORLD-WIDE R&D INDUSTRY

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ABOUT THE COVER

The way people produce designs and layouts is changing rapidly. A part of this change is brought about by a new, large-format plotter from Hewlett-Packard.

The plotter produces engineering and scientific drawings on commercially-available media. It can automatically select up to eight colors, as well as different line widths and fonts. Pens not in use are capped by the instrument.

The plotter accepts precut sheets and preprinted forms of paper, vellum, or polyester film. Repeatability equals that of machines costing twice as much. Resolution is better than that of most comparably-priced units.

Pen acceleration is the fastest available in a plotter of this size. A microgrip mechanism maintains constant positive control of the medium.

For additional versatility, the plotter accepts commands from either a small or a large computer. A related article begins on p. 122.

Technical Publishing

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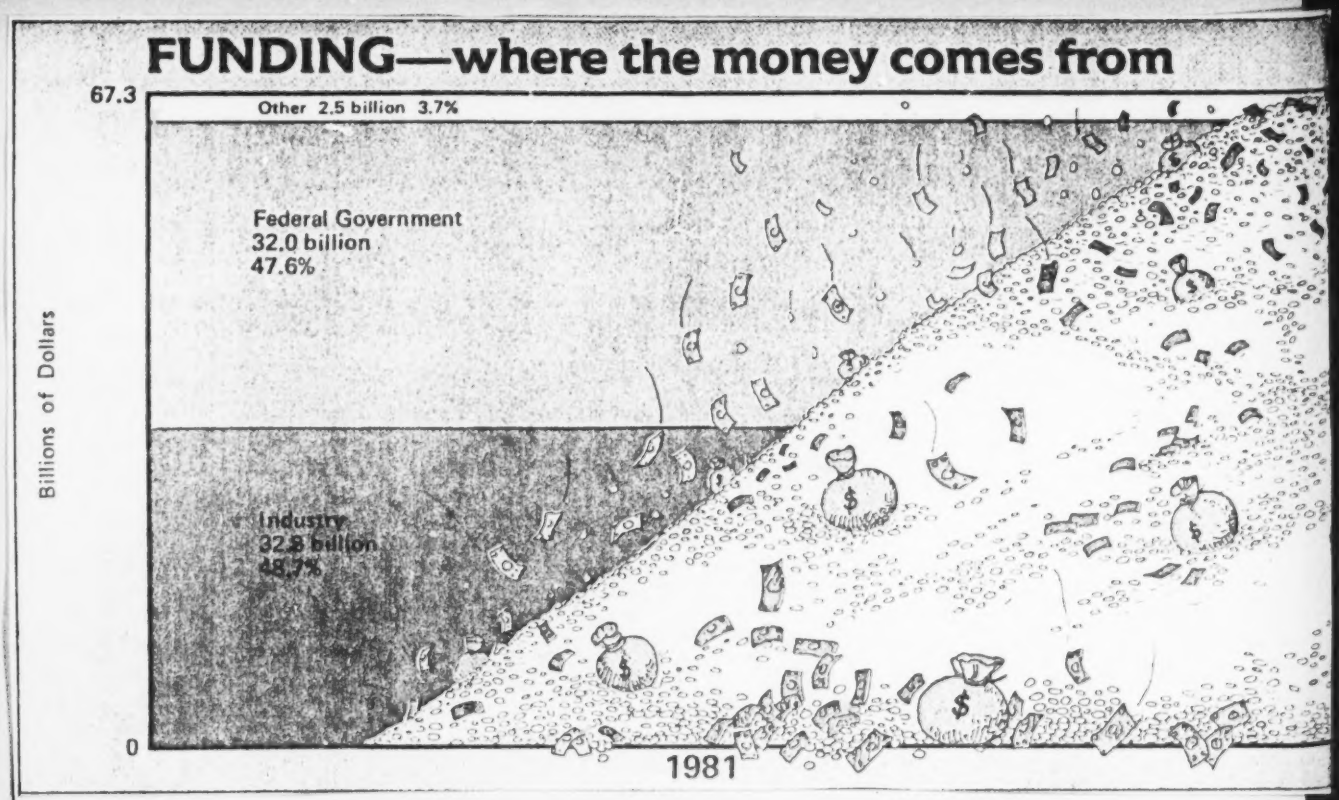


C.J. Mosbacher
Executive Editor, IR&D

More than $67-billion for R&D in '81

Increased funding by industry should offset smaller growth in Federal government funding caused by budget changes both past and potential, leading to an IR&D forecast of $67.3-billion

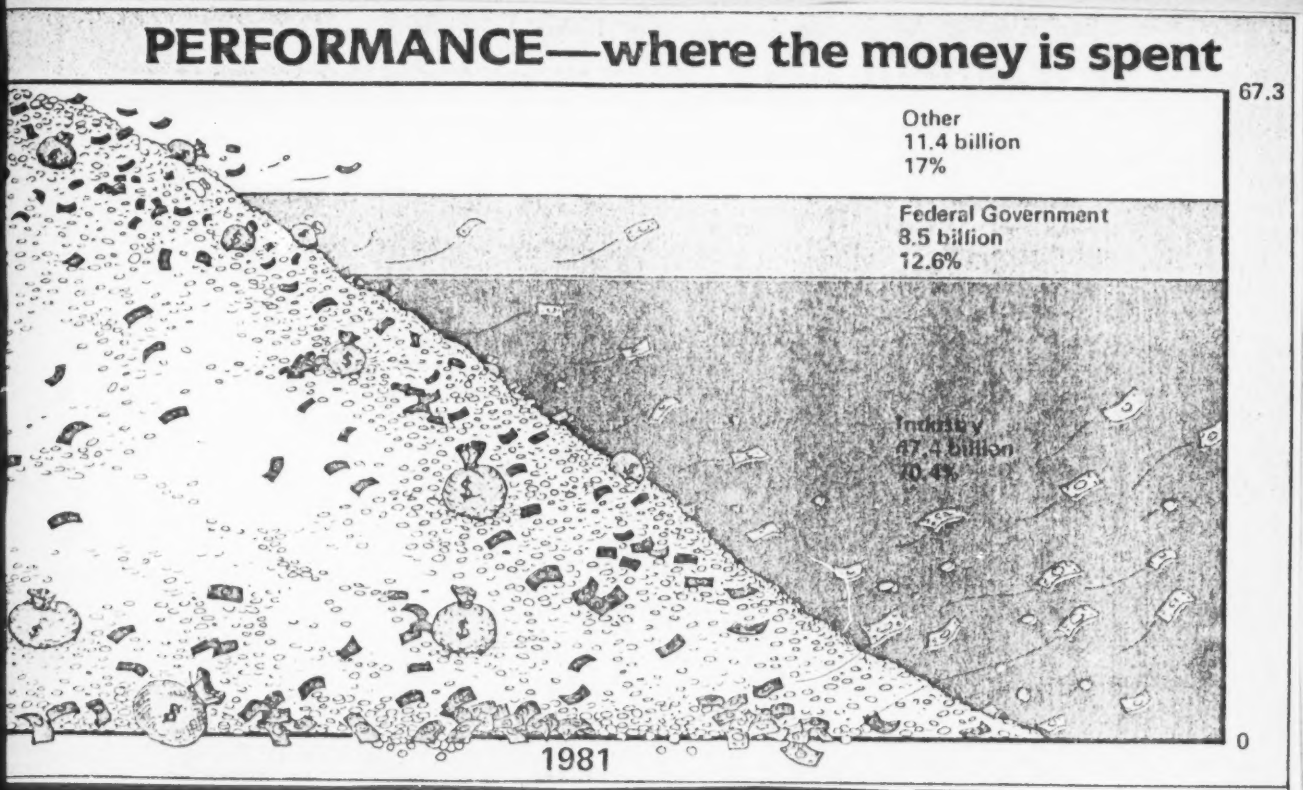
WHILE RECESSION looms over the general economy . . . the R&D sector should continue its steady, slow real growth with funding increases just topping the expected inflation rate. So began the forecast of the 1980 R&D economy on page 103 of this magazine last January. Now, a year later, the same words are true when applied to total funding for R&D.

We expect funds for R&D to total some $67.3-billion in 1981, increasing almost 11.5% from the 1980 level. That's just 1% more than the 10.5% inflation rate that is the consensus of the economic fraternity at the present time for 1981.

But comparing aggregate funding increases with a consumer-price-index inflation rate is at the least misleading when taken as more than a general indication of the health of the R&D economy. More important is a sector-by-sector study of who provides the funds and who does the work. That's the purpose of this forecast.

Each year, we assemble data from the government, trade associations, academic sources, and industry. To enhance these data, we obtain off-the-record information from a number of companies about their R&D budgets for the coming year.

In evaluating these data, the first step we take is to revise our forecast for the



preceding year, essentially adopting the latest revised information from the National Science Foundation as our data base. Our forecast for 1980 was $59-billion, compared to a March, 1979 NSF figure of $57.3-billion. The latest NSF data for 1980 R&D funding (in NSF 80-310, May 23, 1980) give a total of $60.375-billion, including $29.4-billion in Federal government funding. Industry is estimated to provide $28.71-billion, with academic and other nonprofit organizations providing $2.27-billion.

The NSF estimates that the Federal government performed $7.83-billion of R&D in its own laboratories in 1980. Industry performed $42.25-billion, academic and other nonprofits, $10.3-billion.

NSF 80-310 also predicts 1981 funding and expenditures totaling $66.7-billion, with $32-billion from the Federal government $32.21-billion from industry, and sources. Corresponding expenditure levels are $8.5-billion, $47-billion, and $11.2-billion.

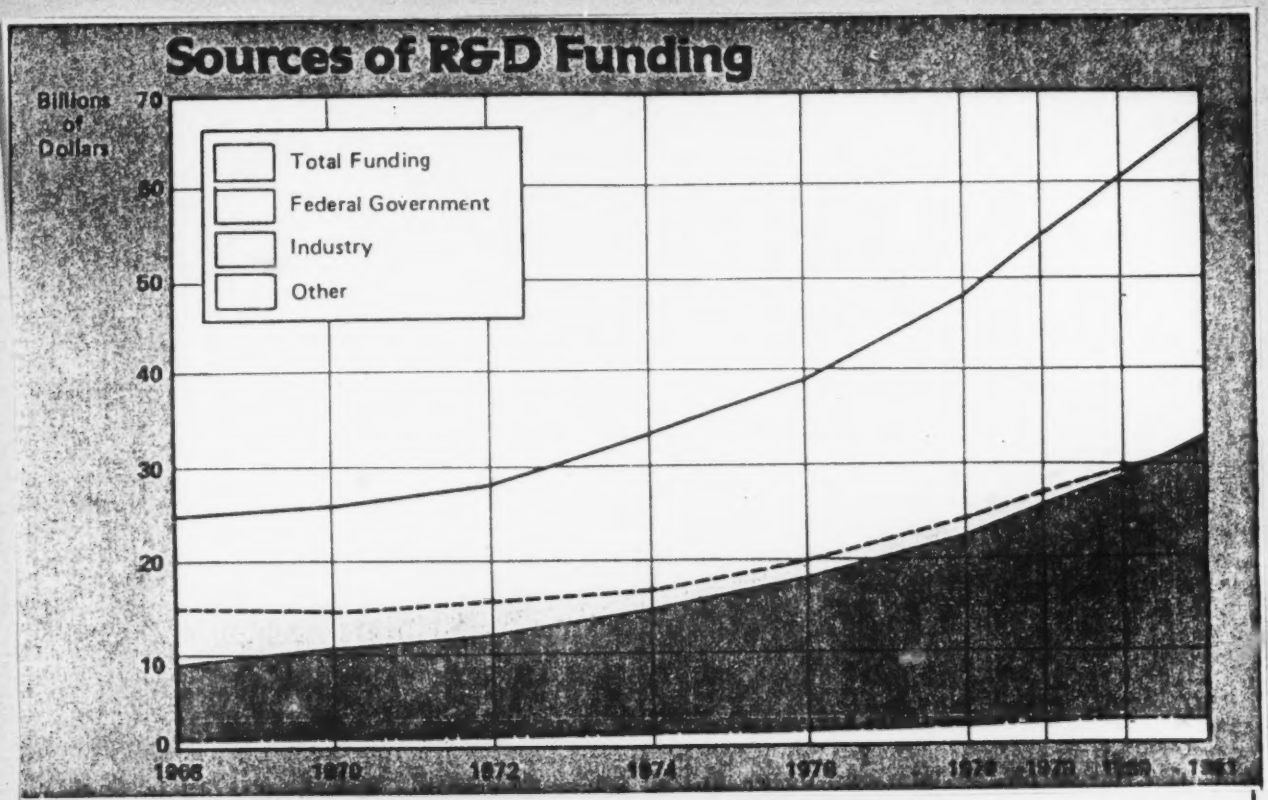
Federal funding lags inflation. While NSF 80-310 took into account a reduction of some $2-billion in President Carter's revised budget for fiscal 1981 to $35.5-billion for R&D, much has happened since. A change in Administrations in Washington, coupled with a Congress that forced the government to operate at fiscal 1980 levels through the first quarter of fiscal 1981 (ending last December 31), clouds any view of Federal funding trends.

Actually, the congressional delay last Fall in passing appropriations should add slightly to calendar 1981 Federal funding. Projects were delayed until funds were made available by Congress, with the exception of the Department of Defense, which received authorization to proceed at the higher funding levels anticipated for the year, 1981.

President-elect Reagan has indicated plans to trim government spending over-all while increasing funding for defense. Certainly R&D has been recognized as a "controllable" expenditure in the past and could well be seen as such once again. We believe, however, that the value of R&D is well recognized by the new President's advisers, and that, while shifts in funds may occur over a period of time perhaps even longer than a year, over-all Federal R&D funding will not change drastically in 1981. Taking into account the lags incurred between the Presidential budget, authorization and appropriation of funds by Congress, obligation of funds by government agencies, and their actual expenditure, we expect Federal funding for 1981 to be in line with the NSF projection of $32-billion. That is an increase of 8.84% from 1980.

We expect the trend of the last few years to continue, with the amount of R&D performed in government laboratories increasing more slowly than other sectors. This leads to Federal government performance of $8.5-billion, an increase over 1980 of only 8.1%. Note, however, that this does not include national laboratories operated by the academic and industrial sectors under contract.

Industry up significantly. Automobile and housing sales may be off, but most of high technology is flying. It's true that R&D in the automotive industry has suf-



fered setbacks, but most of the cutting took place last year. In surveying industry, we were surprised by the commitment to R&D, particularly in high technology, chemical, and energy firms. Planned budget increases for 1981 ranged as high as 25% in firms doing significant amounts of R&D. Few were the firms planning for increases of less than 2% above inflation.

We project that industry funding will total $32.8-billion in 1981, an increase of 14.3% from last year and significantly more than the 12.5% increase from 1979 to 1980.

Performance of R&D in industry won't increase as much. Government-funded projects in industry will grow more slowly than industry's own projects, in line with the smaller growth in Federal funding. We therefore project R&D performance in industry for 1981 as $47.4-billion, an increase of 12.2% over 1980.

Perhaps the most significant point in this forecast is that this is the first year that industry has provided more funds for R&D than the Federal government. (At least that's true from 1953 until now on the basis of the data we have.)

Other sources up 11.7%. Universities, colleges, and nonprofit organizations will provide $2.5-billion for R&D in 1981, increasing their contribution to 3.7% of the total funding from 3.5% in 1980. But their performance climbs only to $11.4-billion, an increase of only 10.7% over 1980. Once again, lagging increases in Federal funds will hold down increased activity. Some easing of the situation is provided by increased industrial funding of academic research, a trend we expect to accelerate in future years.

How much real increase? We've already pointed out the danger of comparing increases in R&D funding to such measures of inflation as the consumer price index. NSF, in providing data in constant 1972 dollars as well as current dollars, uses the "GNP implicit price deflator," a better measure than the consumer price index. But even the GNP deflator does not reflect differences among the sectors in which R&D is performed.

Preliminary studies by Edwin Mansfield of the Wharton school at the Univ. of Pennsylvania suggest that the percentage increase in the real R&D expenditures of major industrial sectors may have been exaggerated by about 50% in government statistics covering the decade from 1969 to 1979. These results were presented at the AAAS Colloquium on R and D Policy on June 19, 1980, in Washington, DC.

At the same meeting, Charles Falk, director of NSF's Div. of Science Resources Studies, commented that one of the division's research projects showed that inflation in the academic sector was actually lower than the GNP deflator in recent years.

Unfortunately, sector inflation rates still are not known precisely. The best we can say is that R&D probably will show some small but real growth in 1981 considering the present economic conditions. If the economy improves as the year progresses, and if the pace of new defense and energy projects funded by the government increases beyond our expectations, 1981 could better our forecast and turn into a banner year for R&D. □

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1981

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Multi-technique surface analysis

Stress analysis by photoelastic testing

Selecting fillers for plastics and coatings

R&D salaries: income vs. inflation

News for and about people in R&D

Photoelastic pattern observed during bearing contact between mating parts

INDUSTRIAL RESEARCH & DEVELOPMENT

SERVING THE $142.5-BILLION WORLD-WIDE R&D INDUSTRY

EDITORIAL

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ABOUT THE COVER

Photoelasticity is a property of a transparent plastic object or coating. When the plastic is subjected to mechanical stress, the object or coating exhibits changes in optical properties. These changes are proportional to the stresses developed.

Polarized light passing through the stressed plastic splits into two beams. The relative phase shift between the beams yields a colored interference pattern.

Using a polariscope, the analyst can determine the principal stress directions. And, by a technique called optical compensation, can determine the magnitude of the stress.

One of the characteristics of this birefringence is the line between red and green color bands, called a fringe. The higher the fringe order, the higher the stress; the closer together the fringes, the more concentrated is the stress in the area shown.

Cover photo furnished by Measurement Group/Vishay. An article describing some practical applications of photoelastic stress analysis begins on p. 124.

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Robert R. Jones
Editor

Substantial pay increases; R&D workers make gains

There is good news in the pay checks of R&D workers who responded to the annual salary survey. Unlike last year's inflation-matching increases, this year's income levels more than keep up with living cost.

THERE'S a lot more to cheer about in the findings of this year's annual IR&D salary survey than there was in last year's. There are strong signs to suggest that workers in research, development, and quality assurance have more buying power than they had a year and more ago.

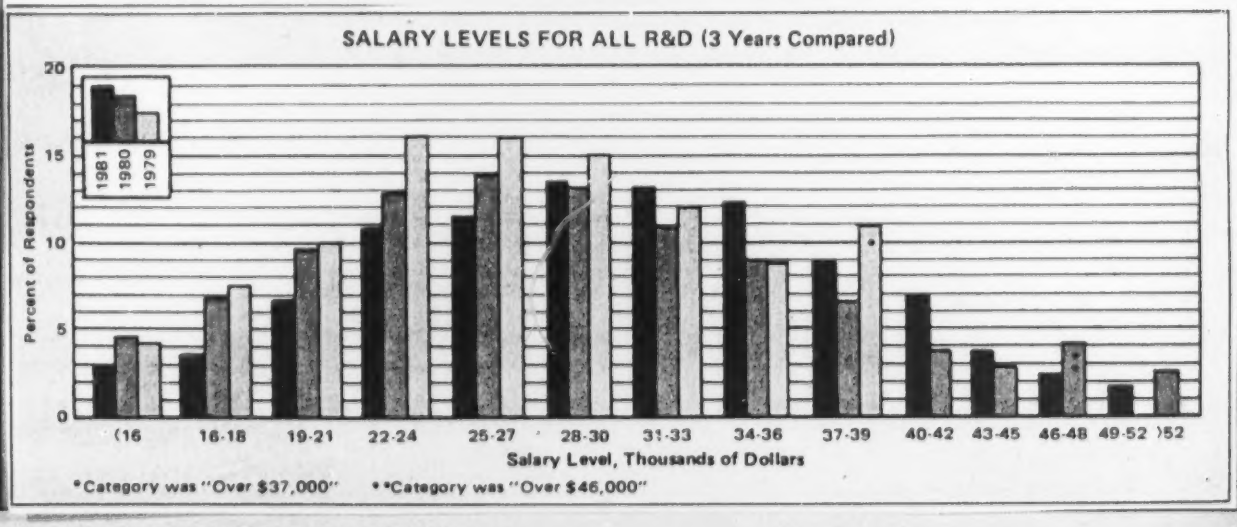
In last year's report we were forced to face up to "the very strong likelihood, if not actual certainty, that average salaries in research, development, and quality assurance have not kept up with inflation."

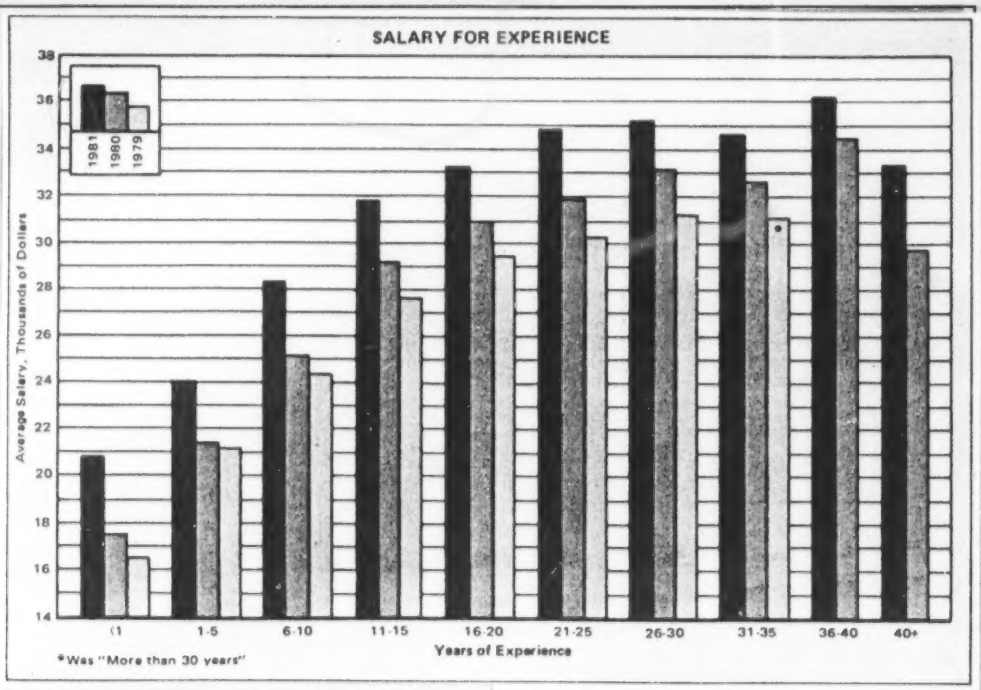
This year's responses from more than 5,850 scientists and engineers show that the entire salary framework has shifted upward by something in the neighborhood of $3,000. This is demonstrated in our chart which shows "Salary levels for all R&D, three years compared."

If you play a connect-the-dots game with the tops of the bars for each year, you will see that 1980 and 1981 (unlike 1979) make similar bell-shaped curves of the distribution of workers throughout the salary ranges. The 1981 curve, however, is offset approximately $3,000 to the right of the 1980 curve.

This little exercise tells us that the entire R&D salary framework has shifted upward. The payoff, of course, is in the individual paycheck, and we'll get to that shortly.

From 1978 to 1979, our studies have shown, the median income for R&D work-





ers increased by nearly 13%. From 1979 to 1980, the gain was only 3.5%, meaning that in most cases, individual increases derived from merit, longevity, or promotion did not add enough to keep buying power up.

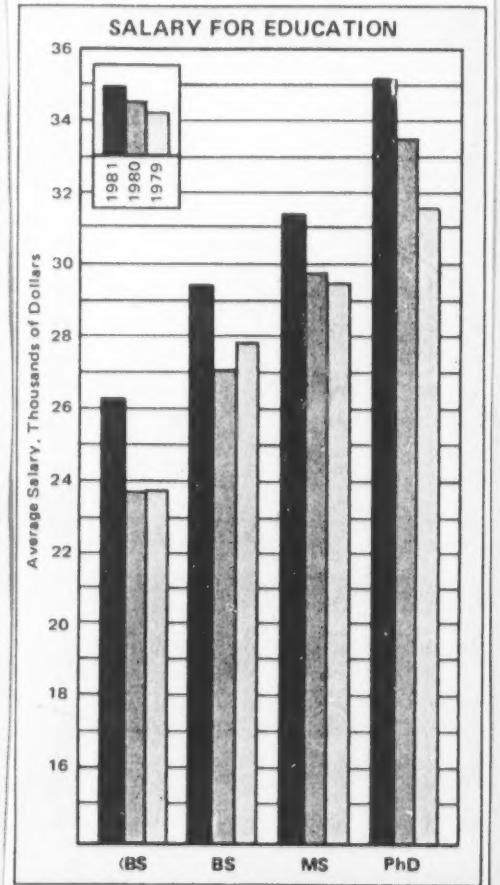
From 1980 to 1981, the industry median income has increased 9.6% and now stands at $31,221. We had used approximately that figure last year when we reported that 37.2% of the respondents were earning $31,000 or more (up from 32% in 1979 and only 13% in 1978). This year's survey finds that more than 51% now are earning $31,000 or more. The new hires coming in at the low end of the pay scale and the retirements dropping off of the high end did not keep the total scale from moving upward.

So much for the industry as a whole. For individuals, pay increases seem to be increasing at an increasing rate. More than 40% of this year's respondents received a pay increase of 10% or more during the past year—enough to keep even with inflation in most communities—compared to 1980's 28.4% and 1979's 26% who did this well. This table shows the three years for each category on the questionnaire:

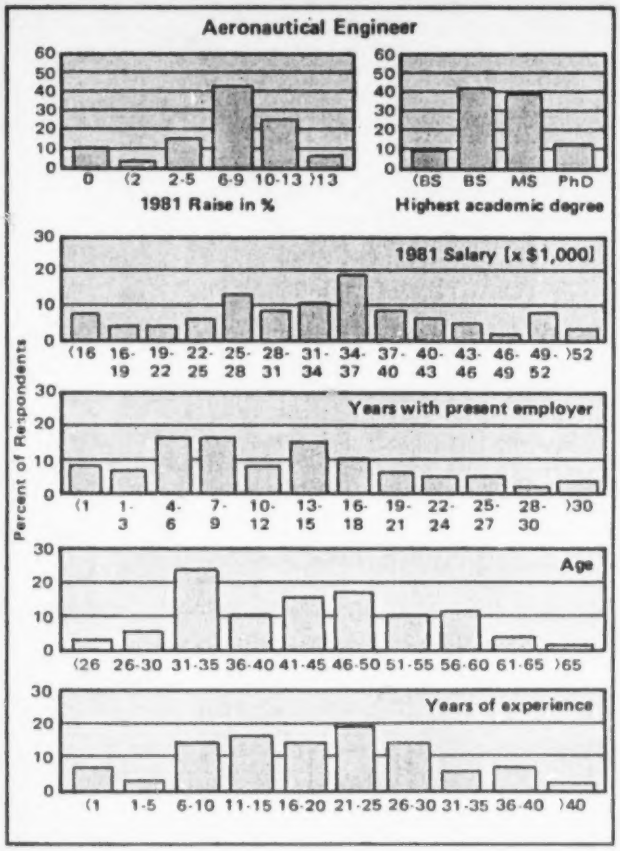
Increases in Salary: All levels R&D

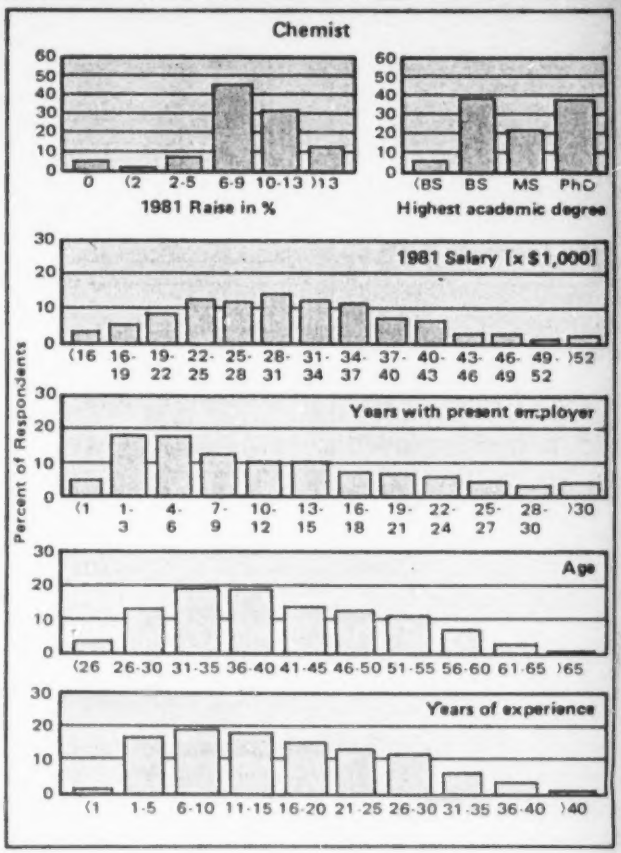
	% of respondents		
Amount	1981	1980	1979
None	5.2	5.7	5.0
<2%	0.9	1.5	1.0
2 thru 5%	8.0	12.4	19.0
6 thru 9%	45.2	52.0	49.0
10 thru 13%	29.7	19.6	20.0
14% or more	11.0	8.8	6.0
Holding even or doing better	40.7	28.4	26.0

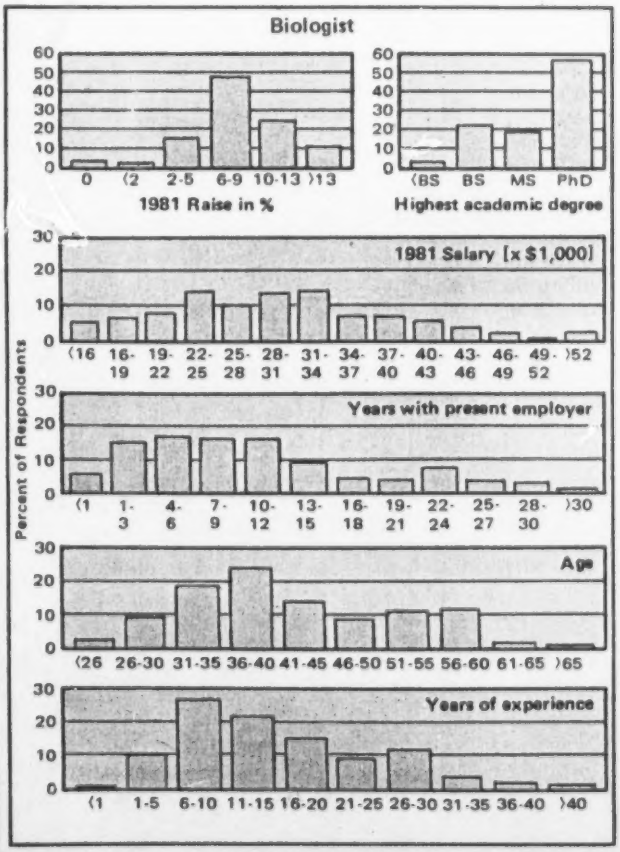
Increases were not evenly distributed throughout the professions this year any more than in past years. Chemical engineers, who had been lagging, made substantial gains. These are detailed, along with five other parameters for the different professions in the accompanying charts.



Looking at the median salary comparisons, mathematicians have stayed in







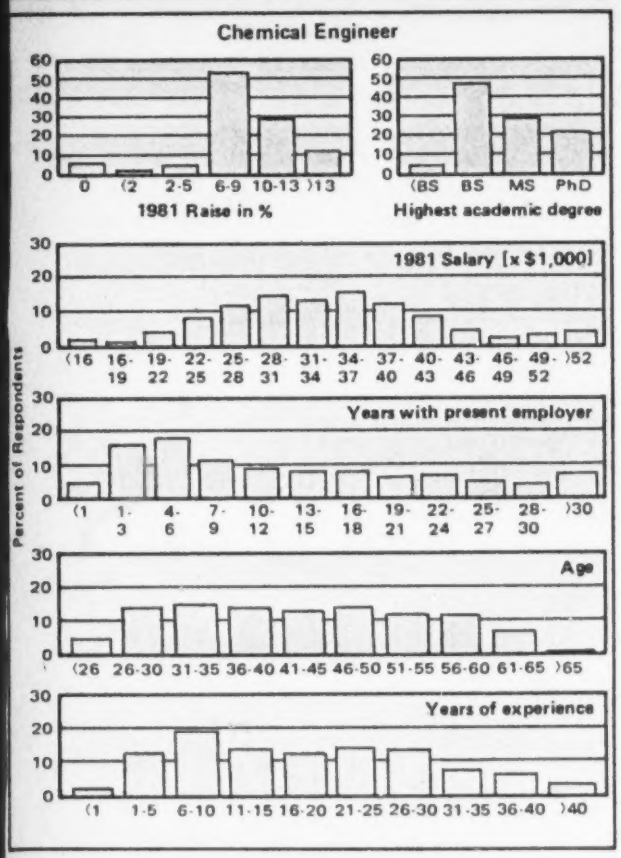
first place while biologists have advanced from eleventh to ninth. The biologists did this with a 14% improvement in their median salary. Chemical engineers logged almost as high a percentage gain, and chemists and electrical engineers held their own by making gains of 11%. Rankings by profession and relative gains are shown in a table.

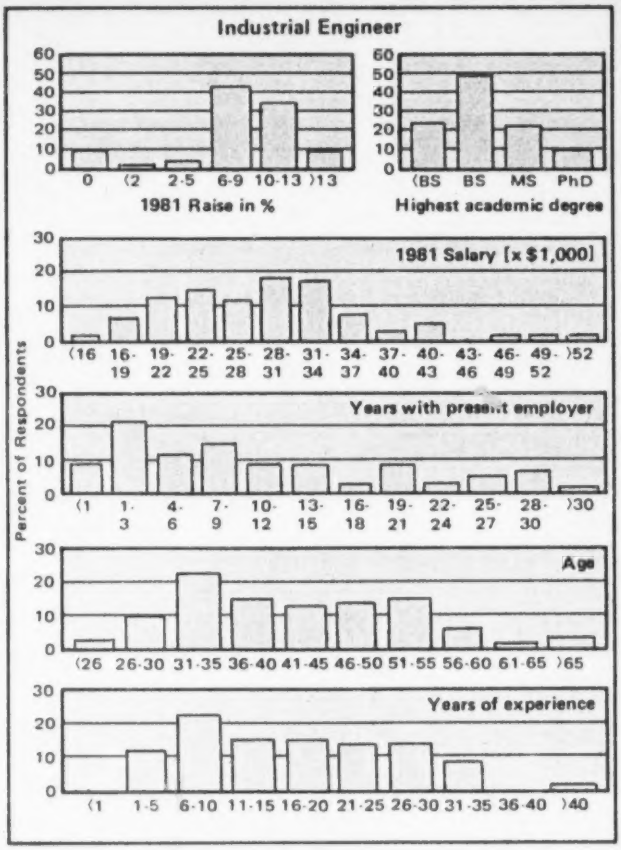
Rankings for professions by median salary

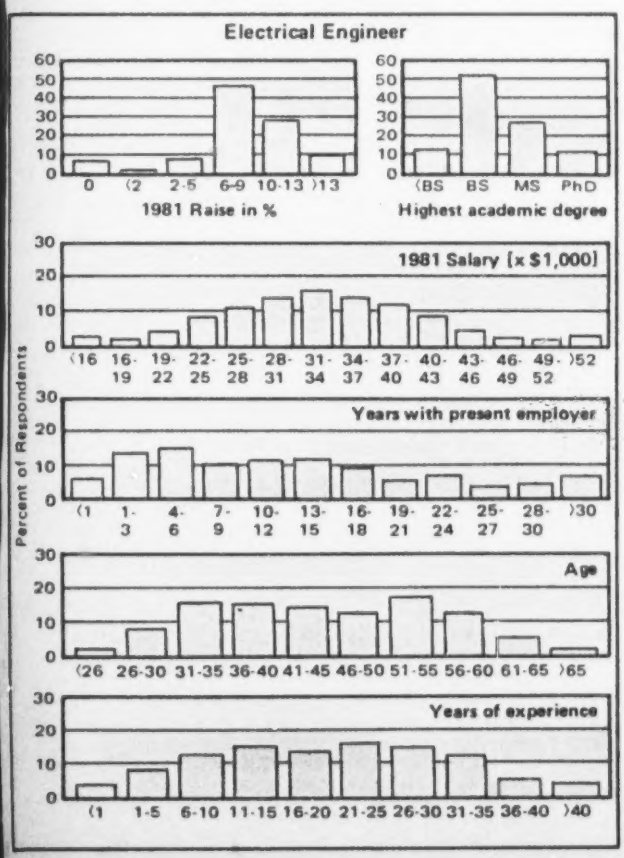
Rank 1981	Rank 1980	Profession	Median salary 1981	Median salary 1980	% increase
1	1	Mathematician	$35,750	$33,099	8.0
2	2	Aero. Engr.	33,950	32,226	5.3
3	7	Chem. Engr.	33,360	29,272	13.9
4	3	Physicist	33,180	31,050	6.8
5	5	Elec. Engr.	33,089	29,635	11.6
6	4	Metallurgist	33,054	30,228	9.4
7	6	Mech. Engr.	32,221	29,480	9.3
8	8	Chemist	30,014	27,031	11.0
9	11	Biologist	29,200	25,561	14.2
10	9	Indust. Engr.	28,750	26,649	7.9
11	10	Other	28,729	26,118	9.9

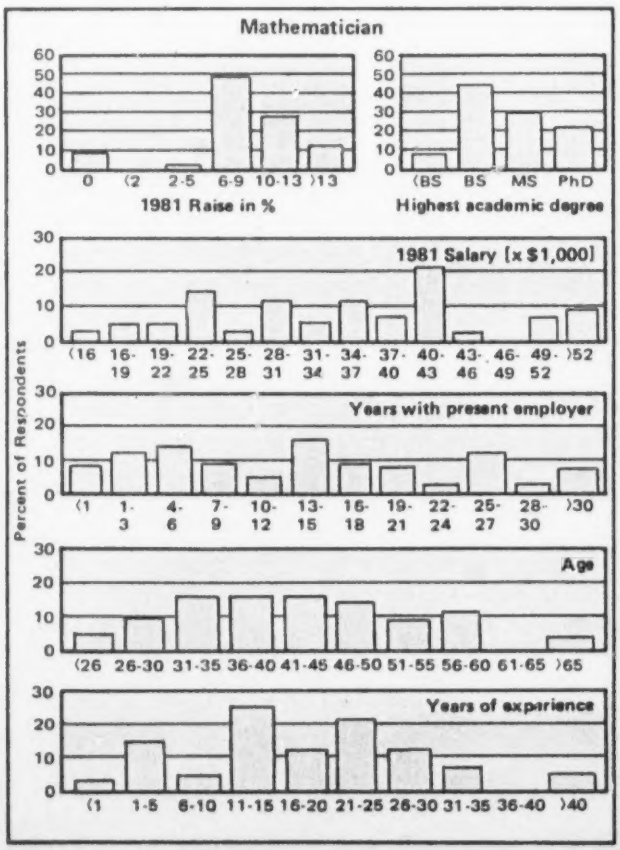
As they have in previous years, biologists lead the other professions by a large margin when it comes to the percent having doctorates. Biologists, at 56.3% PhD, are followed by physicists with 44.5, chemists 37.2, and metallurgists 32.5. Industrial engineers, electrical engineers, and aeronautical engineers have the lowest percentages of PhDs with close to 10% each.

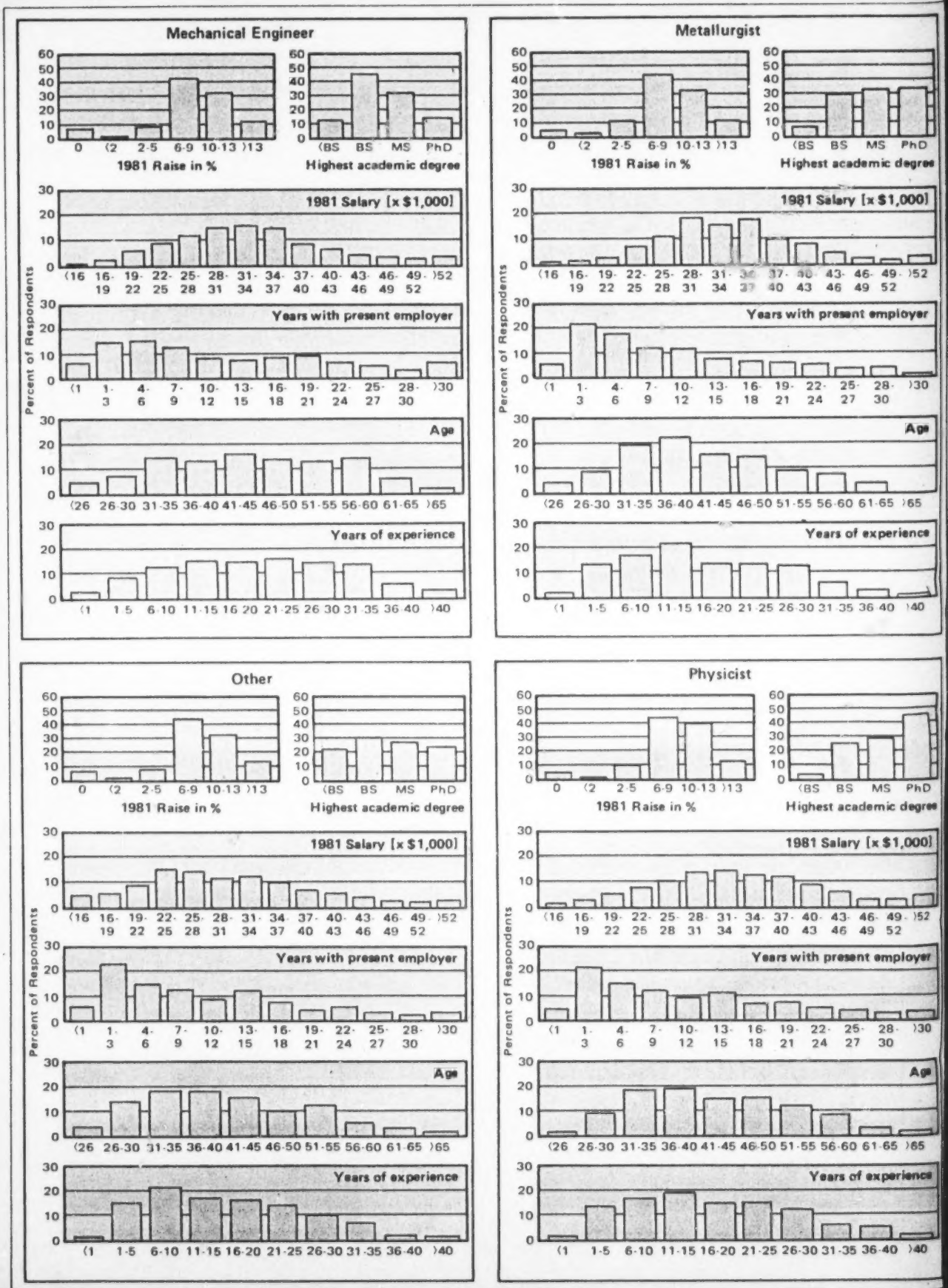
When master's degrees and doctorates are considered together and the pro-


Chemical Engineer
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents


Industrial Engineer
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents


Electrical Engineer
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents


Mathematician
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents


Mechanical Engineer
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents
Metallurgist
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents
Other
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents
Physicist
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents

fessions are ranked for advanced degrees, biologists still lead and physicists are second, but the biologists' lead is greatly reduced. Of the biologists, 76.2% have advanced degrees; physicists are close behind with 73.2, metallurgists are third with 64.7, and chemists fourth at 57.7. Of the nearly 6,000 respondents, 54.6% have advanced degrees.

The value of an advanced degree is reflected in many ways. In dollar and cents terms, the advantages of advanced degrees vary across the professions. For our study group as a whole, median salaries by highest academic degree are compared in the table.

Salaries compared by academic degrees

Degree	Median salary 1981	Median salary 1980	percent change	Annual difference* 1981	Annual difference* 1980	Difference* increase %
Doctorate	$35,161	$32,252	9.0	$4,043	$3,876	4.31
Masters	31,118	28,376	9.7	2,105	2,067	1.8
Bachelor's	29,013	26,309	10.3	3,846	3,310	16.2
<Bachelor's	25,167	22,999	9.4	—	—	—

*Difference above next-lower degree

It is apparent that the advantages of baccalaureate and advanced degrees are increasing. The advantage in annual income for a PhD over less-than-bachelor's this year is $9,994 compared to last year's $9,253 and of the PhD over bachelor's it is $6,148 this year compared to $5,943.

We can expect the holder of a PhD to work approximately 25 years after getting that degree, as our survey shows, with the possibility of a 30-year career for the person who enters the labor force after obtaining a BS. Assuming that an 8% interest rate prevails over this 25-year career, the advantage of the doctorate over an MS is close to $320,000. MS holders would outdo those with only a BS by better than $165,000. A BS compared to no college degree pays off to the tune of more than $300,000.

Projected on the bases just stated, the advantage in the annual salary for a PhD when compared to a bachelor's would provide a career gain of more than $485,000.

Allowing the BS holder five additional income years (while the PhD candidate hits the books), and making adjustments for interest, tuition, etc., etc., worth possibly $195,000, the advantage of the PhD still is in the neighborhood of $290,000—not a bad return for those five years in grad school, since the income is only one of the possible benefits from the degree.

The annual income advantage of a doctorate has increased steadily since 1978 when it was on a plateau, having been in the $2,000-range for three years. In 1979 the advantage was $3,300; 1980's was $3,876, and this year, as noted above, it is more than $4,000.

This fact is emphasized by the information in the following table which shows percentages of degrees in selected salary ranges for all respondents.

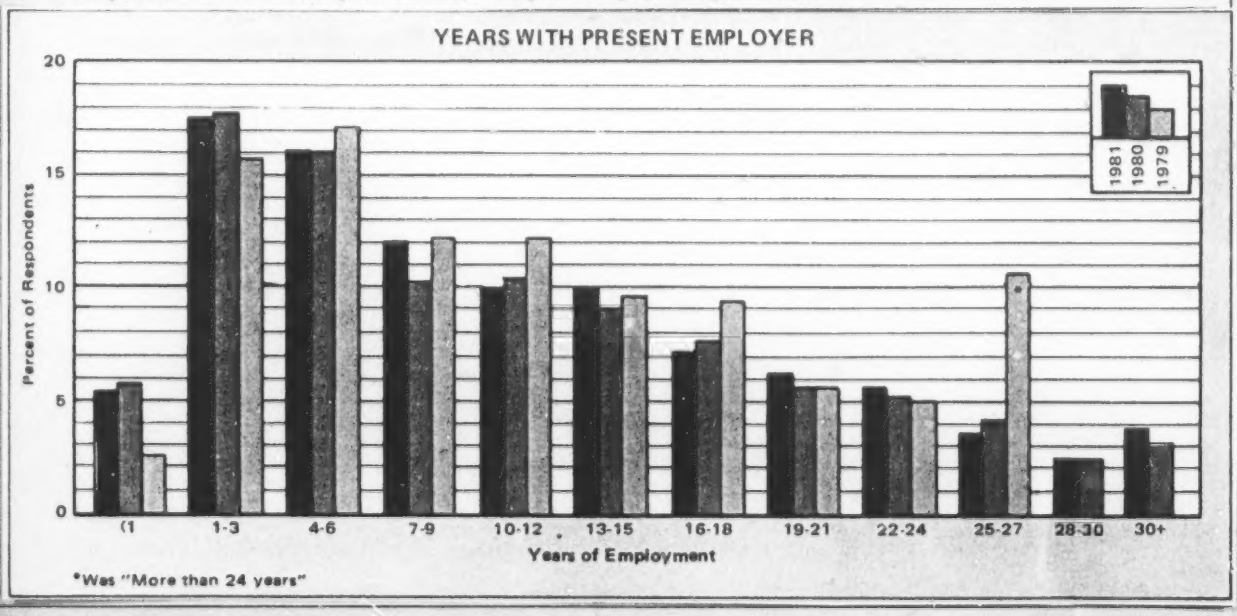
Distribution of degrees for all respondents and in selected salary ranges

Category	<BS	BS	MS	PhD
All R&D	7.9%	37.4%	25.3%	29.4%
$19,000 to $21,999	14.3	51.7	27.1	6.9
$40,000 to $42,999	3.7	24.6	23.1	48.6
$43,000 to $45,999	2.9	19.5	27.6	50.0
More than $46,000	4.4	24.9	22.1	48.6

We would expect the percentages of degrees to be the same in each column if academic accomplishment were not a salary factor.

In the second part of this salary report we will present the salary picture as provided by the same nearly 6,000 respondents when broken into categories of sex and workplace.

When you read that second article you will see that other important changes are occurring in the R&D industry that may affect you and your work. □



INDUSTRIAL RESEARCH & DEVELOPMENT

APRIL 1981

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WASHINGTON DC 20014

Comparative analysis of epoxies by chromatography

Computer automates fluorescence spectroscopy

Do sorption studies with vacuum microbalance

Salaries for women in R&D climbed 18% in 1980

News of importance to people in R&D

Microcapsules can immobilize enzymes as chemical catalysts.

INDUSTRIAL RESEARCH & DEVELOPMENT

SERVING THE $142.5-BILLION WORLD-WIDE R&D INDUSTRY

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ABOUT THE COVER

Enzymes are biological catalysts. When properly immobilized or contained (Aug 1975, p. 49), they can act as catalysts for various liquid-state reactions, many of which have commercial value in industrial processes.

The cover photo depicts red blood cells contained in microcapsules. From 1,000 to 5,000 cells can be held in each of the 500-μm, semiporous Damon capsules.

Membranes of the capsules are made by a patented process from cross-linked sodium alginate and poly-l-lysine. The blue cast in the picture is a reflection of the laboratory flask.

Photomicrograph at 90X by Dr. Allan P. Jarvis Jr., cell biologist at Damon Diagnostics Division, Needham Heights, MA.

A related news story begins on p. 58.

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NEWS OF SCIENCE AND TECHNOLOGY

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110 Equal pay for equal work closer to reality: R.R. Jones, Editor, *IR&D*; place of work still influences remuneration for R&D workers, but the gaps are becoming narrower.

118 Minicomputer gives fast turnaround for fluorometry: C.-N. Ho, I.M. Warner, and M.P. Fogarty, Texas A&M Univ., dedicated mini permits instrument design for rapid data deconvolution.

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138 Bringing lab form and function to 1980s standards: H. Hansen, Herman Miller Inc.; in all areas of lab planning, designers consider flexibility to keep productivity moving.

147 Individual-wafer metallizing system, part 2: F.T. Turner and M. Hutchinson, Varian Assoc. Inc.; close-coupled sideways sputtering leads to automated wafer handling and heating.

Robert R. Jones
Editor

Equal pay for equal work closer to reality in R&D laboratories

Where you work — industry, government, or university — still makes a difference in the paycheck. That spread, however, has gotten noticeably smaller during the past year.

IT IS GETTING more and more difficult to identify general areas of sex-based salary discrimination in the R&D industry. Two years ago it seemed easy to do.

That much change in two years? Yes, if the nearly 6,000 respondents to our survey this year are typical of the R&D industry. Look at the gains that women have made in the median incomes:

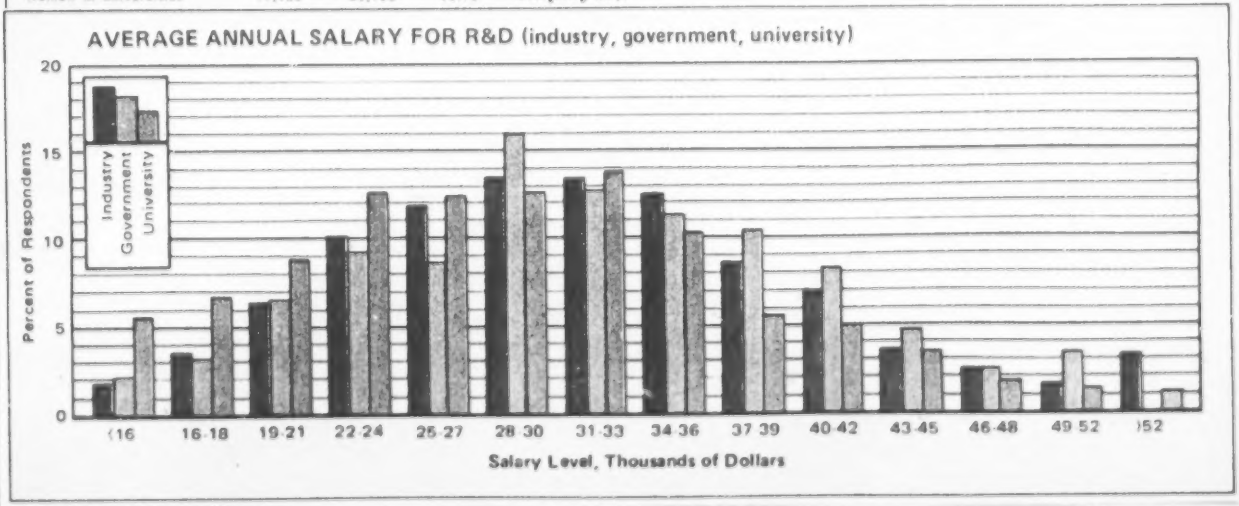
	1980	1981	% gain
Men, all R&D	$28,711	$31,626	10.15
Men in government	30,123	32,405	7.57
Men in industry	28,804	31,730	10.15
Men in universities	26,070	29,006	11.26
Women, all R&D	20,756	24,655	18.78
Women in government	24,786	27,200	9.74
Women in industry	20,372	24,567	20.59
Women in universities	17,123	23,750	38.70

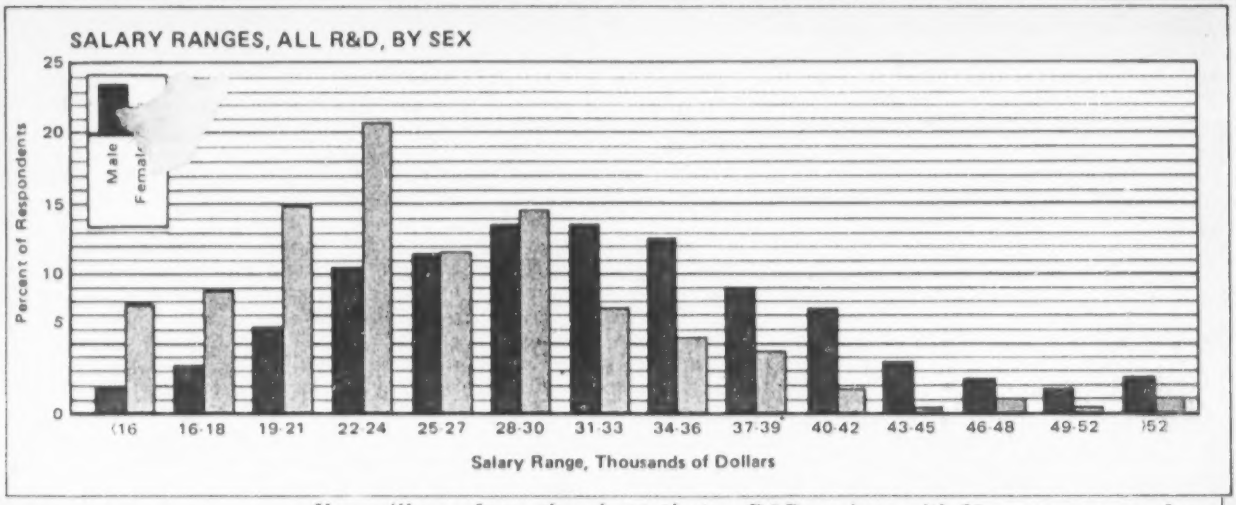
Median income for women R&D workers in industry up 20% last year!! Median income for women R&D workers in universities up nearly 39% last year!! Women outgained men in every category in median income during the past year, but the biggest gains reflect the impact of federal funds being coupled with EEOC pressures in research grants to universities.

Gains for women, yes, but still a long way to go. More than 78% of the women respondents earn less than $31,000 per year; just over half that percentage of men are in that salary range. Looking at it from the other side, only 22% of the women respondents earn $31,000 or more while 53% of the men do.

Since we began reporting results of this annual study with separate figures for male and female, it has become obvious that—while sex discrimination did and probably still does exist—not all of the differences in males' and females' salaries in R&D can be blamed on sex discrimination.

Women in R&D have fallen far short of men in categories of education, experience, and longevity (time with the present employer).





You will see from the chart that women working in R&D have far less experience than their male counterparts. In fact, some of the comparisons are virtually unchanged from last year's. Median experience for males and females last year was 16.97 and 8.14 years; this year it is 16.30 and 8.44. Workers with more than 20 years' experience last year for men and women were 38.3 and 16.1%; this year the figures are 38.5 and 16.2%.

The big change in experience is in the low end of the scale. Whereas 40.1% of the women had less than six years' experience in the 1980 study, only 30.4% of this year's respondents are in that range. This could, in part, reflect lower hiring rates, as we noted for some industry-wide categories in last month's article.

As we have noted over the years, experience is an important factor in salary level. And as before, women still are not in the positions to claim the big paychecks that so often go with long experience in R&D.

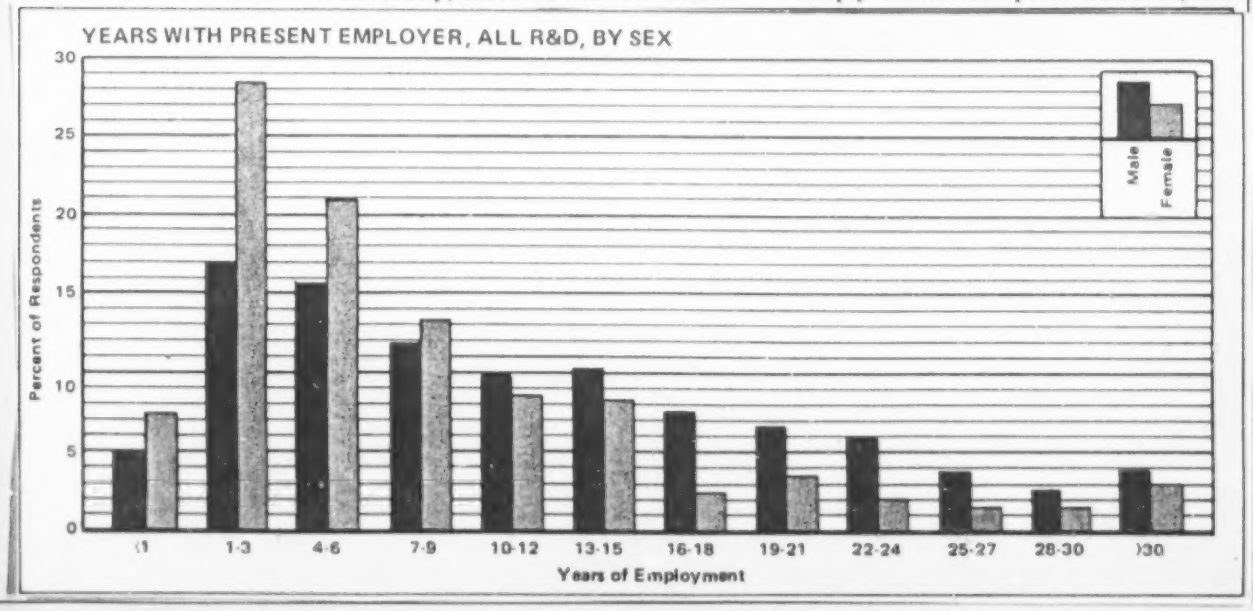
Obviously, there will be few women R&D workers with 20 or more years of experience when 75% of the female respondents are 40 years of age or younger. Less than half of the men responding are that young.

The same imbalance holds true for advanced education. This year, the advantage of a PhD over a bachelor's degree, works out to $6,148 per year—projectable to some $320,000 over a 30-year career, as was detailed in the earlier article (March).

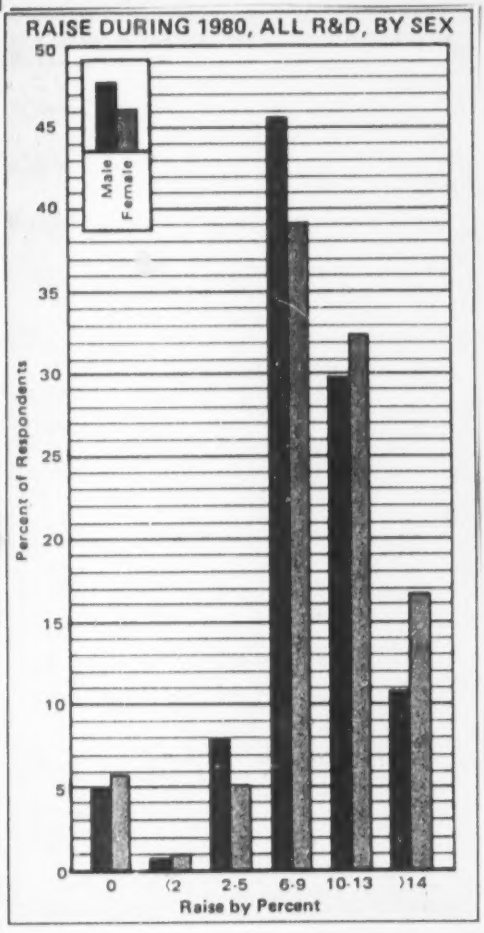
And, as with women's job experience, so women's advanced education (or lack of it) keeps them out of the upper salary echelons. This year's figures differ from last year's by less than our sampling error except in the women PhD tally which increased from last year's 14.0% to 16.9% (women PhD divided by total women respondents).

Even then, the percentage of women with PhDs is only a little more than half of the men's 30.3%.

When it comes to time with present employer, women—for many good reasons—simply cannot compete. However, the



contrast is not quite so great this year. Women with fewer than seven years with the present employer now make up 56.7% of the respondents compared to 1980's 62.8%. And, women with seven through nine years with the present employer are at 13.2%, vs. last year's 10.3.



But there is more to the salary imbalance. The workplace is a factor. Whether you work for industry, government, or university makes a difference in the probable size of your paycheck. And R&D women biologists are most likely to be working in a university.

Just as they led the way with raises last year, so women lead in this survey. While gains in median salary, mentioned earlier, are related to raises, they can be a result of a promotion or combination of raise and promotion.

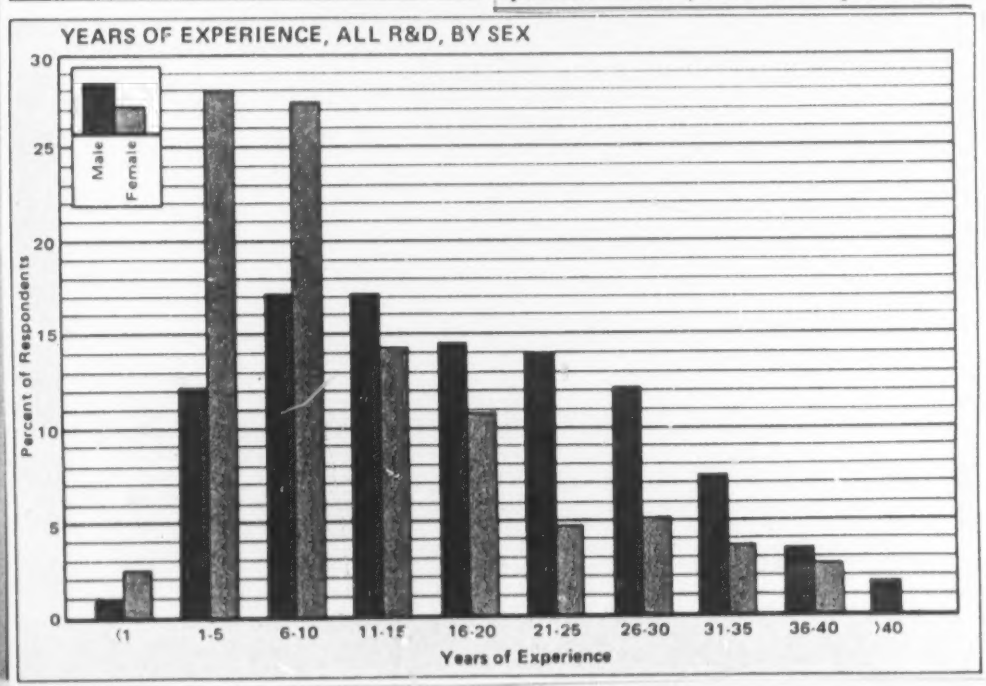
Where raise alone is considered, 7.6% of all raises of 14% or more last year went to women who made up just 5.1% of our population. These figures are nearly the same as last year's.

Nearly 17% of the women respondents, better than one in every six, received a raise of 14% or more last year. Nearly 50% (including those above) received an increase of more than 9% last year. For men, the figures are 11% getting raise of 14% or more and 40% in the total group getting more than 9%.

Salary differences which have favored government jobs so much in recent years are much smaller this year. Government R&D workers still lead in the $36,000 to $46,000 ranges, but the leads are smaller and the range has been reduced in width.

Looking at the ages of our respondents, we find that 62% are in the 30 to 50 age group, about the same as last year. However, the number younger than 30 has dropped from 23% to 17.6, possibly reflecting reduced hiring rates in the recession period.

Last year, for the first, we noted what may be the results of changes in retirement policies. In 1979, none of the professional



categories had more than 1% in the older-than-65 groups. Last year three categories, industrial engineers, metallurgists, and mechanical engineers, showed more than 1% older than 65.

If this year's nearly 6,000 respondents are typical of our industry, then the number of R&D scientists and engineers staying past the old mandatory retirement age of 65 definitely is on the increase. Eight professional categories have at least 1% over 65.

A word of explanation probably is in order about the "others" category. With 12% of our respondents, this is the second-largest category among the respondents, ranking behind chemists and ahead of electrical engineers and physicists.

Because this category runs a steady 10 to 12% in all of our Opinion Poll surveys, we probed deeper earlier this year in a Poll directed exclusively at the "others."

We found out that many of the "others" are persons who consider themselves too specialized for the general categories. A theoretical physicist, for example, who does not feel comfortable in the "physicist" category.

Two sizable groups in the "others" have been identified as ceramicists and geologists.

Much additional information about the people who work in research, development, and quality assurance is provided in the charts which accompany this text.

Following are the complete results of the Opinion Poll survey of nearly 6,000 workers in R&D:

1981 IR&D Salary Survey

Everyone gained in R&D salary sweepstakes; women gained the most.

	All R&D	Male R&D	Female R&D
1. What is your annual salary (Thousands)?			
a. Less than $16	2.6%	1.9%	7.8%
b. $16 thru $18	3.7	3.4	8.8
c. $19 thru $21	6.7	6.2	14.9
d. $22 thru $24	10.9	10.4	20.7
e. $25 thru $27	11.4	11.4	11.5
f. $28 thru $30	13.6	13.6	14.6
g. $31 thru $33	13.2	13.6	7.5
h. $34 thru $36	12.1	12.5	5.4
i. $37 thru $39	8.7	9.0	4.4
j. $40 thru $42	6.9	7.3	1.7
k. $43 thru $46	3.6	3.8	0.3
m. $46 thru $48	2.4	2.4	1.0
n. $49 thru $51	1.7	1.8	0.3
o. More than $52	2.5	2.6	1.0
2. Your raise during the past year was ...			
a. None	5.2%	4.9%	5.8%
b. Less than 2%	0.9	0.8	1.0
c. 2 thru 5%	8.0	8.0	5.1
d. 6 thru 9%	45.2	45.7	39.1
e. 10 thru 13%	29.7	29.8	32.3
f. 14% or more	11.0	10.8	16.7
3. How long have you worked for your present employer?			
a. Less than 1 yr.	5.3%	5.0%	7.4%
b. 1 thru 3	17.5	17.0	28.4
c. 4 thru 6	16.0	15.7	20.9
d. 7 thru 9	12.0	11.9	13.2
e. 10 thru 12	9.8	9.9	8.4
f. 13 thru 15	10.0	10.2	8.1
g. 16 thru 18	7.2	7.5	2.4
h. 19 thru 21	6.2	6.5	3.4
i. 22 thru 24	5.7	5.9	2.0
j. 25 thru 27	3.6	3.8	1.4
k. 28 thru 30	2.6	2.7	1.4
m. More than 30	3.8	3.9	3.0
4. What is your age?			
a. Under 26	3.0%	2.5%	11.5%
b. 26 thru 30	10.7	10.0	25.7
c. 31 thru 35	17.8	17.3	20.6
d. 36 thru 40	17.3	17.4	16.6
e. 41 thru 45	14.1	14.6	7.1
f. 46 thru 50	12.2	12.6	5.4
g. 51 thru 55	11.6	11.9	6.1
h. 56 thru 60	8.8	9.0	4.4
i. 61 thru 65	3.5	3.5	2.4
j. Over 65	1.0	1.1	0.3
5. How many years of experience do you have?			
a. Less than one	1.5%	0.9%	2.4%
b. 1 thru 5	12.8	12.1	28.0
c. 6 thru 10	17.5	17.1	27.4
d. 11 thru 15	16.9	17.1	14.2
e. 16 thru 20	14.2	14.4	11.8
f. 21 thru 25	13.4	14.0	4.7
g. 26 thru 30	11.7	12.1	5.1
h. 31 thru 35	7.2	7.4	3.7
i. 36 thru 40	3.4	3.4	2.7
j. More than 40	1.5	1.5	0.0
6. What is the highest degree you hold?			
a. Less than BS	7.9%	7.7%	4.1%
b. Bachelor's	37.4	36.7	52.5
c. Master's	25.3	25.2	26.4
d. Doctorate	29.4	30.3	16.9
7. What is your profession?			
a. Chemist	37.1%	36.3%	58.2%
b. Chemical engr.	8.1	8.2	6.5
c. Mech. engr.	9.5	9.7	2.7
d. Elec. engr.	11.1	11.3	2.0
e. Aero. engr.	1.5	1.5	0.0
f. Ind'l engr.	1.4	1.4	1.0
g. Physicist	8.9	9.0	6.8
h. Metallurgist	5.1	5.3	0.3
i. Biologist	4.6	4.4	9.5
j. Mathematician	0.7	0.7	1.0
k. Other	12.0	12.1	11.9
8. Do you work in ...			
a. Industry	77.7%	77.8%	79.3%
b. Government	14.3	14.2	15.5
c. University	8.0	8.0	5.2

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Small companies are the most inventive

Microscope lens system controls reflectivity

Microprocessor, micro-computer, microscope

News of importance to people who work in R&D

Sharp photos made from poorly reflective crystals, see page 106.

INDUSTRIAL RESEARCH & DEVELOPMENT

SERVING THE $142.5-BILLION WORLD-WIDE R&D INDUSTRY

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ABOUT THE COVER

For materials of low reflectivity, microscopy often is difficult. Unless special precautions are taken, indistinct or blurred images may result.

Most nonmetallics, including coal, plastics, and other organics fall into this category. In addition, it often is difficult to distinguish similar alloys under ordinary illumination.

The cover photo depicts a mixture of two aluminum alloys using an 8 by 10-in. instant camera attachment on a Zeiss Axiomat-Nomarski differential interference contrast Planachromat at 250X.

Shown above is an 80X photo of a mixture of strongly birefringent crystals (olivine) made in the same way. A related article begins on p. 106.

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NEWS OF SCIENCE AND TECHNOLOGY

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130 **Selecting graphics terminals for best long-term results:** Dean Bailey, Tektronix; common hardware and software of graphic terminals.

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140 **Linear analyzer improves detection in radio-TLC tests:** H. Filthuth, Laboratorium Prof. Dr. Berthold; technique provides sensitivity.

147 **Trends in vacuum equipment in the '80s:** C.J. Mosbacher, executive editor, *IR&D*; materials handling in vacuum.

John J. Gilman
Gilman & Sutter
Amoco Research Center

Small company—big contribution in 'inventivity'

The ratio of patents produced to available funds gives a means for measuring a company's performance. Data indicate an inverse relation between company size and inventivity.

GENERAL OPINION suggests that smaller industrial corporations are more inventive than larger ones. But what is the evidence? And how strong is that evidence? To answer these questions, I have studied the rate at which patents are produced by various corporations that received the most U.S. patents during 1977.

As might be expected, more patents were granted to large corporations than to small ones—probably because they had more people working in their engineering and research operations. Therefore, the patenting rates were "normalized" by dividing them by the sales revenues of the corresponding corporations during the same year. I then plotted these normalized patenting rates against the annual sales revenues.

In the rest of this discussion, normalized patenting rates will be named "inventivities." This name has been chosen to suggest that this parameter is a subclass of productivity. It is the ratio of patents produced to sales revenues. In other words, it is the output that given input resources can produce.

Inspection of these comparative data indicates that the inventivities of firms with given sales revenue rates are nearly inversely proportional to the sales rates. Statistically, there is a strong inverse dependence in this log-log linear plot. Letting P = number of patents, and S = sales in billions of dollars, the correlation coefficient is 0.79—that is, relatively high correlation. The regression line is given by:

$$\ln(P/S) = 4.32 - 0.692 \times \ln(S)$$

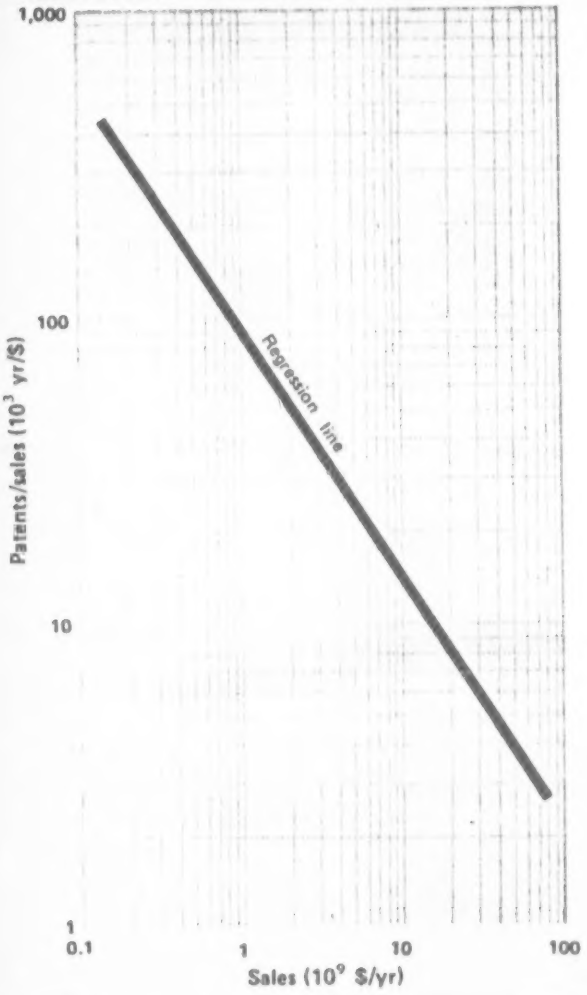
with a standard estimated error of 0.59. Since the slope coefficient is about 0.7 rather than 1.0, the dependence is not linearly inverse, but it is not far from it.

What does this correlation mean? It is doubtful that the independent variable is the inventivity. If this were the case, the results would suggest that deliberate suppression of inventions would tend to increase sales revenues by very large amounts. Adherents to conspiracy theories sometimes propose this, but it seems highly

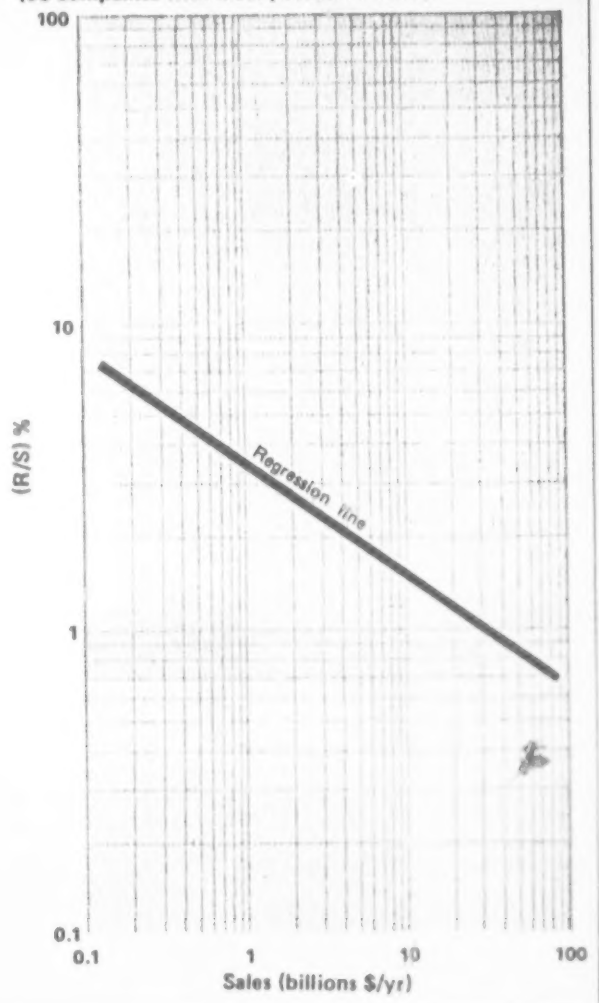
Comparison of inventivities for various companies

Company	$ (Billions)	Patents/ Sales	R/S (%)
Westinghouse	6.14	79	2.2
RCA	5.88	73	2.2
Caterpillar Tractor	5.85	57	3.8
Dow Chemical	6.23	48	3.3
Phillips Petroleum	6.26	43	0.8
Eastman Kodak	5.97	42	5.9
Rockwell International	5.86	29	1.7
Occidental Petroleum	6.01	18	0.5
Union Oil of California	5.87	10	0.3
Sun Oil	6.42	8	0.4
International Harvester	5.98	8	1.9

Correlation of inventivity with sales revenues
(95 companies with most patents in 1977)



Correlation of research expenditures with sales
(95 companies with most patents in 1977)



Comparison of companies with high and low inventivity

15 Highest			15 Lowest		
Company	P/S	R/S(%)	Company	P/S	R/S(%)
Xerox	97	5.3	General Motors	5	2.6
Motorola	116	5.9	Exxon	5	0.4
Upjohn	175	9.0	Texaco	7	0.2
Polaroid	112	8.4	Mobil Oil	6	–
Stouffer Chemical	94	2.6	Standard Oil (Calif)	7	0.4
AMP	172	9.2	Ford Motor	3	3.1
Bell & Howell	140	5.1	Standard Oil (Indiana)	8	0.6
Robertshaw Controls	251	2.3	U.S. Steel	8	0.5
Illinois Tool Works	195	1.6	Gulf Oil	4	0.4
Beckman Instruments	194	7.8	Atlantic Richfield	6	0.4
Nalco Chemical	105	3.3	Continental Oil	7	0.3
Eli Lilly	90	8.2	Sun Oil	8	0.4
Corning Glass	90	4.9	International Harvester	8	1.9
American Cyanamid	88	4.0	ITT	12	2.1
Merck	84	8.4	General Foods	11	0.1
Averages	134	5.7	Averages	7	1.0

unlikely for the large sample of companies.

Instead, the data may suggest that as an industrial corporation grows in its sales revenues, the production of inventions becomes less important in relation to other factors. The other factors may include financial strength, production skills, marketing tactics, raw materials supplies, and other such items.

One might be thinking that large corporations spend relatively less on invention activities than smaller ones do. This possibility was investigated by studying the normalized rates at which the same set of corporations spend their funds on research.

To evaluate the data, we plotted a log-log regression line for the relation of relative research expenditures to total sales. In this case, the correlation coefficient is only 0.4—about half as large as that of the data comparing inventivity to sales revenues. It may be concluded from this that normalized research spending depends more on the qualitative characteristics of a company than on its quantitative size as an operating unit.

One way to investigate how the qualitative characteristics of corporations affect their inventivities is to examine a set of firms lying within a narrow band of sales/year values. For example, the band that extends from $5.5 to $6.5 billion per year contains eleven companies.

These companies all have nearly the same sales revenues. On the other hand their inventivities vary by an order of magnitude from 8 to 79 patents/billion sales dollars. The relative amounts that they spend on research also varies by an order of magnitude. Yet inspection of the data shows only a weak correlation between their inventivities and research spending.

No significant qualitative pattern is evident. Still, the oil companies do tend to lie lower on the list than the equipment manufacturers.

A much stronger indication of the importance of qualitative factors is provided by considering the two sets of companies with the highest and lowest average inventivities, respectively. Those chosen are the 15 with the highest inventivities (P/S greater than 83), and the 15 with the lowest (P/S less than 13).

Inspection of the lists is consistent with the general reputations of the companies. Most of those in the highest inventivity list have reputations for doing substantial amounts of research, and for making product innovations based on research results. Those on the lowest inventivity list do not.

We note also that the companies on the highest list spend an average of 6% of their sales revenues on research and development, while those lowest on the list spend only 1% on average. In this latter case, even if the "oil companies" are eliminated, the R&D expenditures average about 2%.

The data presented here are for a single year. It seems unlikely that other years would yield dramatically different results. Yet it might be desirable to study similar data for additional years.

The cost of producing a patent is a parameter of interest. From the trends we have noted, it is clear that patents cost more in larger than in smaller firms.

For example, consider two imaginary firms that represent average behavior: one at the $10 billion sales level; the other at the $0.1 billion dollar level. The average value of R/S for the companies studied is 0.032. Therefore, from the regression line, the larger firm would spend (in 1977) about $2 million of R&D funds to produce a patent.

On the other hand, the smaller firm would spend only about $87,000—only about 4% as much as the larger firm. This might mean that much of what is spent for "R&D" in large firms is not directed toward making inventions. It also may mean that they do not spend the funds as efficiently as smaller firms.

In either case, a problem exists in the larger firms. There is either a problem of clarification so that management understanding can be improved, or a problem of spending the available resources to achieve more effective results.

If a majority of people agree that the national inventivity of the U.S. needs to be improved, then serious consideration should be given to the very strong influence of organizational size. What is true of commercial organizations very likely is also true of government and so-called non-profit organizations.

Thus we see that within existing organizations, means should be found for decentralizing authority to help create a sense of "smallness." The loss of fiscal efficiency that this might entail would be far less than the large potential gain in inventivity that should result.

It is important to keep in mind, of course, that while inventions play a crucial role in the process of innovation, the results presented here do not conclude that innovation correlates inversely with corporate size. Too many other factors play important roles in cause and effect.

Nevertheless, the very strong inverse dependence of inventivity on size should be taken into account when strategic plans are being made—both within corporations and external to them within society at large. □

THE AUTHOR

Dr. John J. Gilman is manager of corporate research at Standard Oil Co. of Indiana, Amoco Research Center, Naperville IL. A graduate of Columbia Univ., his interests include the direction and coordination of corporate research, as well as bringing new products to the marketplace. Dr. Gilman's R&D specialties include metallic glass materials, Alexandrite lasers, and new chemical processes. He has been active in both industrial and university R&D programs.

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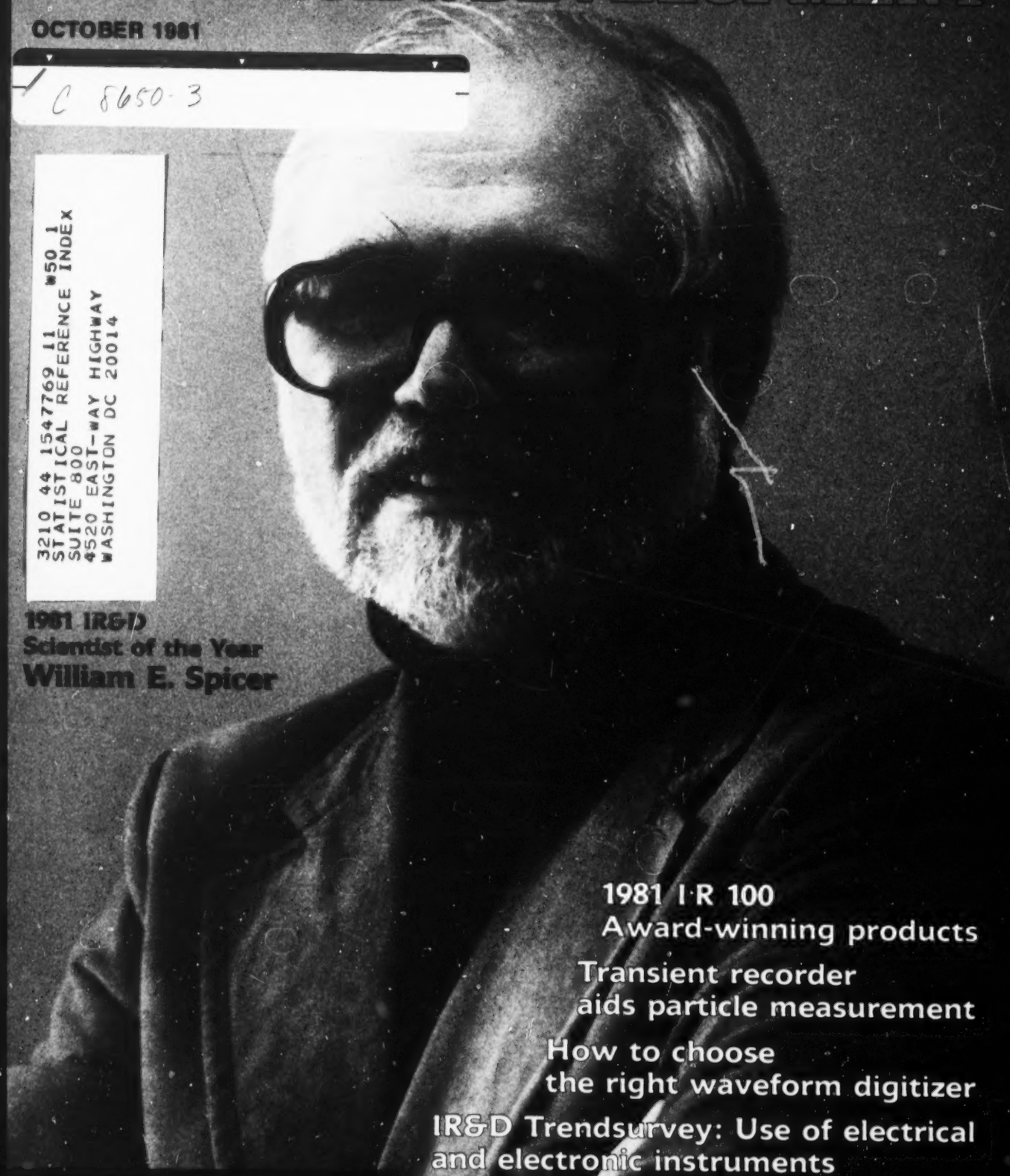

1981 IR&D Scientist of the Year
William E. Spicer

1981 I·R 100
Award-winning products

Transient recorder
aids particle measurement

How to choose
the right waveform digitizer

IR&D Trendsurvey: Use of electrical
and electronic instruments

News of importance to people in R&D

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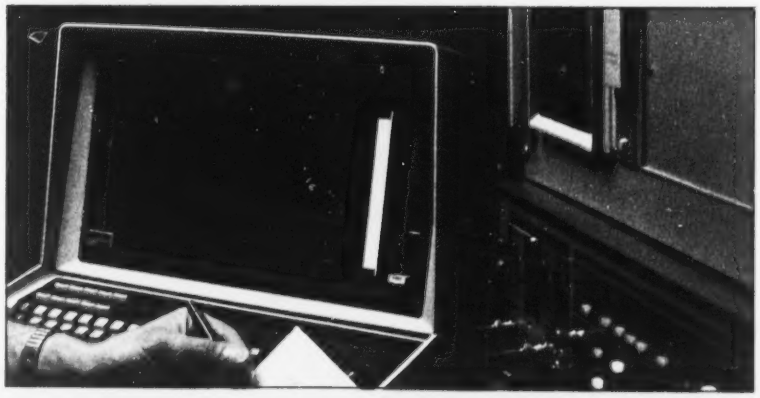
Waveform digitizer improves quality of measurements. See p. 174.



INDUSTRIAL RESEARCH & DEVELOPMENT

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ABOUT THE COVER

"When I look back on my career, I realize that if I had been allowed to be only a pure scientist, which is what I intended to be when I left graduate school, I would have had a very limited career."

So says Dr. William E. Spicer, *IR&D*'s 1981 Scientist of the Year. In his early work, he discovered how to use photoemission as a tool in solid state physics.

At the present time, Spicer uses photoemission spectroscopy and synchrotron radiation to study the top layers of solids. He and his coworkers also are studying processes and reactions in the materials important in the working of a computer.

"One of the real problems we face today is the schism between pure science and applied science . . ." he says. ". . . young scientists should learn how to think . . . of concepts . . . [They] must get used to the idea that we are all on one team . . ."

An article about the 1981 Scientist of the Year begins on page 171. Cover photo for *IR&D* by Chuck Painter, Stanford News Service.

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NEWS OF SCIENCE AND TECHNOLOGY

59 **Science Policy:** Brookhaven's Isabelle accelerator faces budgetary cutbacks; NSF provides $11 million for experimental computer science research; R&D in fiber optic cabling gets $50 million boost from British Government.

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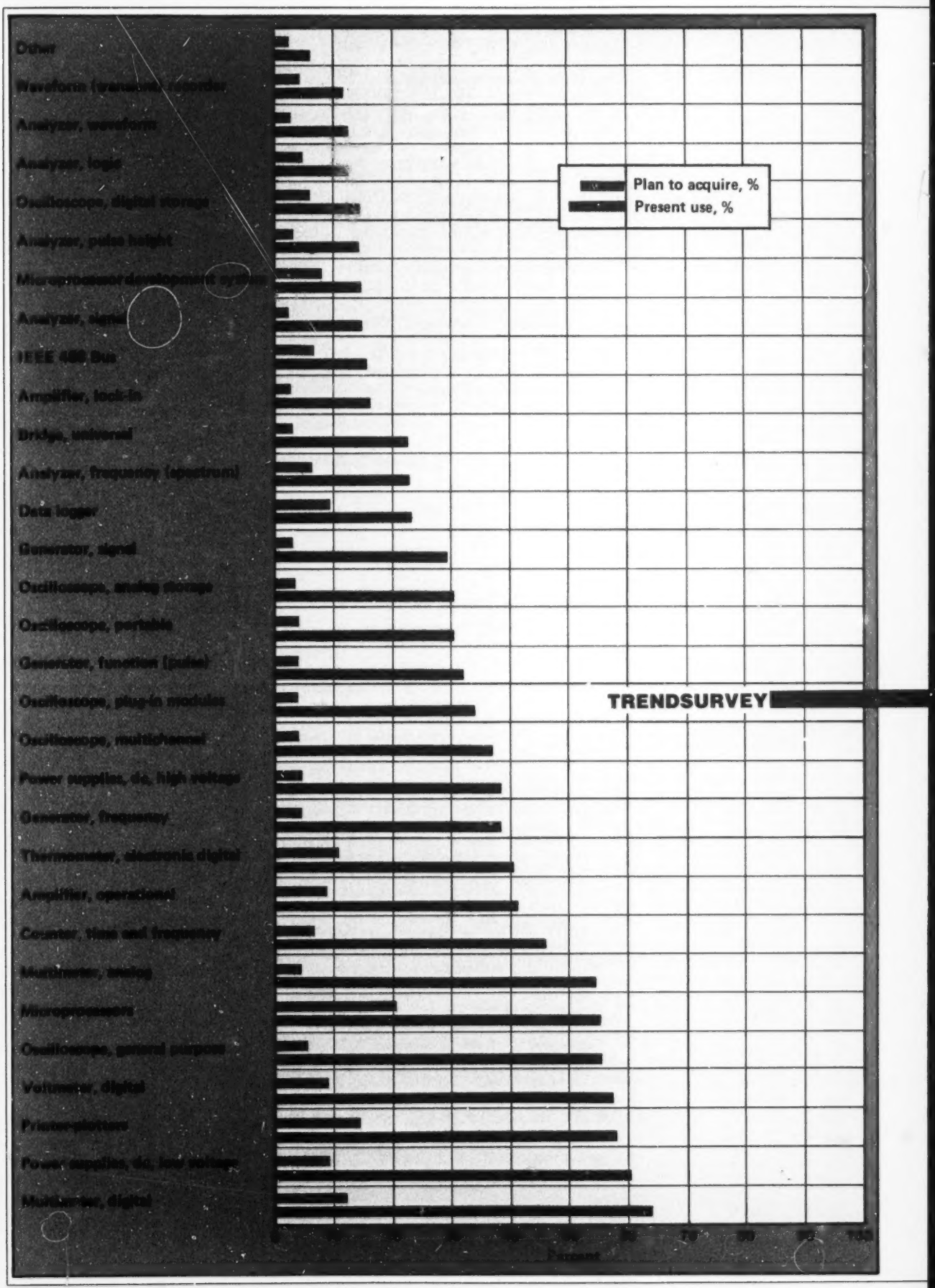
196 ***IR&D* survey of electrical and electronic instrument usage:** C.J. Mosbacher, executive editor, *IR&D*; even when corrected for changing job emphasis, plans to purchase new equipment decline.

201 **"Charge-Rate" ion gaging system measures pressure:** J.J. Sullivan, MKS Instruments; simple circuit converts ion current to frequency to provide a digital display of pressure in scientific terms.


Other
Waveform (transient) recorder
Analyzer, waveform
Analyzer, logic
Oscilloscope, digital storage
Analyzer, pulse height
Microprocessor development system
Analyzer, signal
IEEE 488 Bus
Amplifier, lock-in
Bridge, universal
Analyzer, frequency (spectrum)
Data logger
Generator, signal
Oscilloscope, analog storage
Oscilloscope, portable
Generator, function (pulse)
Oscilloscope, plug-in modules
Oscilloscope, multichannel
Power supplies, dc, high voltage
Generator, frequency
Thermometer, electronic digital
Amplifier, operational
Counter, time and frequency
Multimeter, analog
Microprocessors
Oscilloscope, general purpose
Voltmeter, digital
Printer-plotters
Power supplies, dc, low voltage
Multimeter, digital
Plan to acquire, %
Present use, %
TRENDSURVEY
Percent

C.J. Mosbacher
Executive Editor

Use of electrical and electronic instruments

While demographic changes in readers responding to this year's survey mask the extent of the drop, it's evident that plans to acquire new instruments are lower than last year, with growth rates in many categories declining as a result.

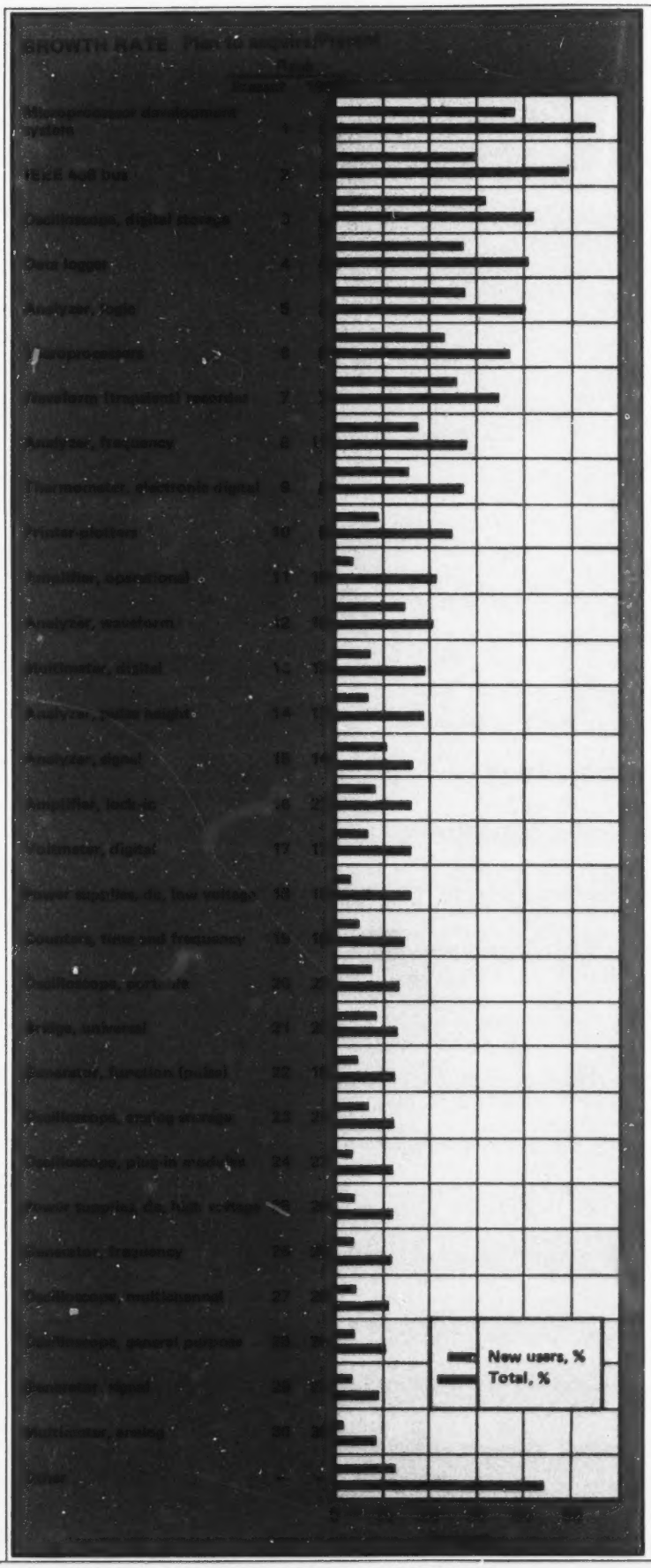
PLANS TO ACQUIRE electrical and electronic instruments within one year, averaged over the 30 categories listed in the IR&D Trendsurvey, dropped from 6.8% in 1980 to 6.2% in the 1981 results just tabulated. That's a decrease of almost 9%. But engineers, who normally have the highest present use and plans to acquire electronic instruments, are a smaller part of the total sample this year, down almost 7% from 1980. Conversely, life scientists and medical researchers represent almost 11% of the 1981 respondents, an increase of almost 3% over 1980.

Representation measured by other demographic categories such as job function and employer also changed slightly. Our interpretation of the results is that plans to acquire at best equal those of last year on average but most probably are about 2% less than in 1980 on the "unit" basis that is implied in the structure of the Trendsurvey. Measured on a cost basis, with increasing prices, plans to acquire electrical and electronic instruments probably are therefore higher in 1981 than they were in 1980. In other words, price increases have certainly been higher than 2%, and in many cases, than 9%.

The importance of digital instrumentation once again is confirmed, with the top six instruments in growth rate (plans to acquire based on present use of each type) all being digital. In fact, with minor shifts in order, these are the same six types that led in 1980. Notably, however, the top growth rate fell from 72.6% to 54.1%.

Results of the Trendsurvey are presented graphically on these pages. Present use and plans to acquire are graphed as a per cent of the total number of respondents on the facing page. Growth rates are summarized in the chart on the next page, which gives the total growth rate and the rate for new users—those who indicated they do not presently use an instrument but who plan to acquire it in the next year. Note that growth rates are calculated on the basis of present use, not on the total sample base used in the first illustration. Complete data giving numbers of respondents as well as percentages for the total sample and disciplines is given on the last page of this article.

As can be seen from the table, 45.3% of respondents gave engineering as their primary dis-



cipline, 42.0% physical science, and 10.8% life science or medicine. In 1980, the corresponding breakdown by discipline was 48.4%, 42.2%, and 7.9% respectively.

By employer, 60.0% of respondents work in industry, 17.3% in universities, 6.3% in nonprofit organizations, 2.0% in medical research centers, and 12.1% in other areas including government. In 1980, the corresponding numbers were 59.8%, 16.3%, 6.0%, 1.9%, and 13.5%.

By job function, 4.9% are corporate officers, 7.1% R&D executives, 16.5% project management, 66.2% professional staff, and 4.0% other. Last year, the 1980 numbers were 4.2%, 7.5%, 18.1%, 63.9%, and 5.0%. This demographic profile differs considerably from that in the IR&D circulation; this same discrepancy has been noted in all Trendsurveys to date. We believe that this is caused by those using instruments directly being more inclined to answer this survey.

In geographic terms, the distribution of respondents correlates well with the IR&D circulation, which in turn correlates with R&D funding and activity in the United States. New England accounts for 6.4% of the respondents to the 1981 Trendsurvey, the Middle Atlantic 17.3%, East North Central 16.1%, West North Central 5.1%, South Atlantic 13.4%, East South Central 3.5%, West South Central 6.6%, Mountain 6.3%, and Pacific 17.7%.

Average present use, without the "Other" category, declined from 33.7% in 1980 to 33.2% in the present Trendsurvey. Plans to acquire, calculated on the same basis, as noted earlier dropped from 6.8% to 6.2% for the total sample.

Variations in present use and plan to acquire averaged over the 30 categories (without other) was quite wide. Corporate officers gave present use of 29.9%, plans to acquire of 8.3%; on average; R&D executives 34.2% and 11.1%; project managers 36.0% and 7.8%; professional staff 32.8% and 5.6%; and other, 34.4% and 5.1%, respectively for present use and plan to acquire.

By discipline, the averages were 39.9% and 7.9% for engineering; 29.2% and 5.6% for physical science; and 22.2% and 4.1% for life science and medicine.

By employer, results were surprising. Industry present use and plans to acquire were 31.3% and 6.3%; universities 40.1% and 7.5%; nonprofit organizations 41.0% and 6.1%; medical research centers 30.5% and 6.9%; and other employer (including government) 32.9% and 5.9%. We suspect that the large plans of the university contingent were based on proposed Federal funding of instrument purchases that since have been eliminated from the budget.

As with earlier Trendsurveys, this study was conducted by including a prepaid reply postcard in a mailing to domestic IR&D subscribers in late May. By August 7, 1,449 cards had been returned. Ten cards could not be used because of multiple answers to demographic questions, leaving 1,439 respondents represented here. □

Growth rate (left) is calculated with present use as base for each instrument category. Total includes all those who plan to acquire; new users are those who do not presently use that particular instrument but who plan to acquire. Difference is present users planning to acquire additional or replacement instruments or equipment.

PRESENT AND PLANNED USE— data from 1,439 respondents

	Engineering, 652		Physical science, 605		Life science or medicine, 185			Engineering, 652		Physical science, 605		Life science or medicine, 185		Present users who plan to acquire		New users
No.	%	No.	%	No.	%	%	No.	%	No.	%	No.	%	%	No.	%	%
252	16.1	100	15.2	115	19.0	14	9.0	10	1.5	25	4.1	3	1.9	10.4	19	8.2	8.2
681	43.5	302	46.3	240	39.7	40	25.8	66	10.1	54	8.9	7	4.5	11.1	107	18.1	3.6
387	24.7	197	30.2	106	17.5	22	14.2	63	9.7	25	4.1	3	1.9	36.1	34	10.4	17.7
307	19.6	126	19.3	33	5.5	16	10.3	40	6.1	22	3.6	8	5.2	40.0	22	12.2	27.8
207	14.4	72	11.0	115	19.0	14	9.0	13	2.0	20	3.3	5	3.2	35.8	25	12.1	6.8
179	12.4	112	17.2	50	8.3	14	9.0	27	4.1	8	1.3	1	.6	28.6	12	6.7	14.0
314	21.8	126	19.3	62	10.2	24	15.5	18	2.8	14	2.3	4	2.6	19.0	14	6.5	10.3
334	23.2	204	31.3	90	14.9	23	14.8	28	4.3	13	2.1	1	.6	10.9	14	4.3	8.6
492	34.2	383	58.7	215	35.5	55	35.5	56	8.6	32	5.3	6	3.9	14.6	61	9.2	5.1
403	28.0	178	27.3	119	19.7	31	20.0	71	10.9	53	8.8	10	6.5	30.1	45	13.6	27.1
427	29.7	327	50.2	188	31.1	30	19.4	39	6.0	20	3.3	3	1.9	11.1	44	8.0	3.4
479	33.3	274	42.0	157	26.0	22	14.2	34	5.2	20	3.3	3	1.9	12.1	36	7.8	4.8
435	30.2	267	41.0	128	21.2	20	12.9	27	4.1	12	2.0	1	.6	5.7	25	5.9	3.5
199	13.8	132	20.2	79	13.1	11	7.1	57	8.7	43	7.1	8	5.2	36.2	43	19.3	29.6
797	55.4	378	57.9	327	54.0	83	53.5	149	22.9	116	19.2	26	16.8	27.1	191	24.0	13.2
328	22.8	148	22.4	49	8.1	9	5.8	74	11.3	30	5.0	9	5.8	34.1	33	15.8	38.3
785	54.5	406	62.3	312	51.6	52	33.5	38	5.8	25	4.1	1	.6	6.4	53	6.8	1.5
931	64.7	470	72.1	379	62.6	57	36.8	94	14.4	70	11.6	7	4.5	19.1	110	11.9	7.2
445	30.9	260	39.9	142	23.5	33	21.3	31	4.8	18	3.0	6	3.9	12.1	24	5.5	7.1
256	17.8	148	21.3	55	9.1	6	3.9	53	8.1	26	4.3	6	3.9	32.1	21	10.2	32.0
788	54.7	428	65.9	304	50.2	56	36.1	49	7.5	23	3.8	6	3.9	10.2	49	6.1	4.0
531	36.9	321	49.7	169	27.9	36	23.2	40	6.1	15	2.5	3	1.9	11.1	35	6.6	4.5
494	34.3	283	43.4	166	27.4	29	18.7	37	5.7	16	2.6	3	1.9	12.8	40	8.3	3.7
441	30.6	261	40.0	150	24.8	23	14.8	39	6.0	18	3.0	2	1.3	10.3	26	5.9	7.5
693	48.1	246	37.7	243	40.2	53	34.2	27	4.1	32	5.3	6	3.9	11.3	44	8.0	3.8
969	67.3	458	69.9	334	55.2	63	40.6	78	12.0	47	7.8	8	5.2	8.5	110	12.7	3.0
834	57.9	368	56.1	382	63.1	73	47.1	103	15.8	84	13.9	19	12.3	24.7	127	15.2	9.7
683	47.4	306	46.9	223	36.9	48	31.0	86	13.0	56	9.3	14	9.0	17.7	69	11.8	15.4
635	44.1	435	66.7	317	52.4	63	40.6	64	9.8	55	9.1	10	6.5	9.1	18	9.2	6.6
190	13.2	103	15.8	52	8.6	13	8.4	34	5.2	23	3.8	1	.6	14.1	14	8.3	26.0
90	6.2	46	6.4	32	5.3	9	5.8	13	2.0	13	2.1	4	2.6	54.7	19	21.8	12.6

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